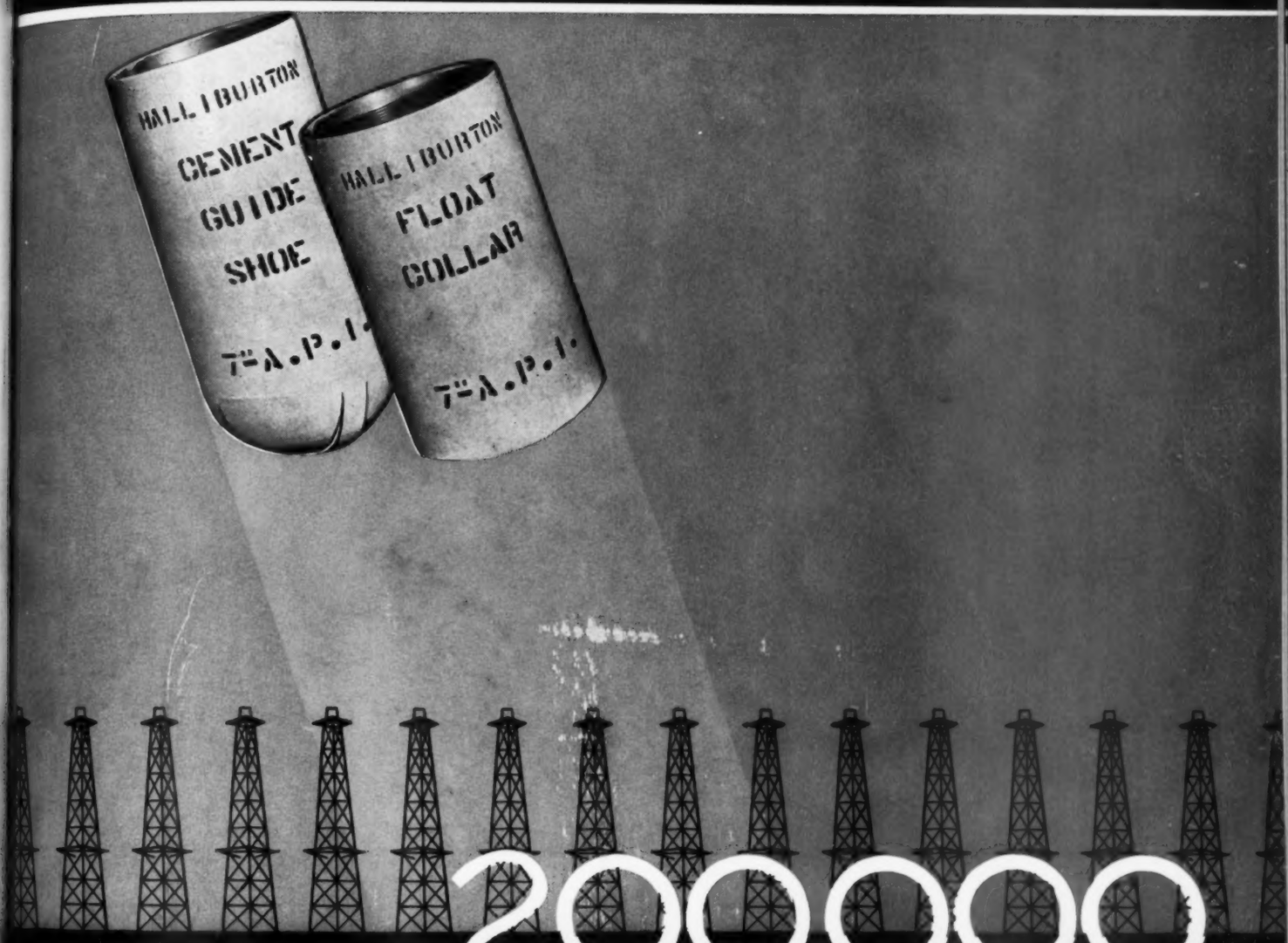

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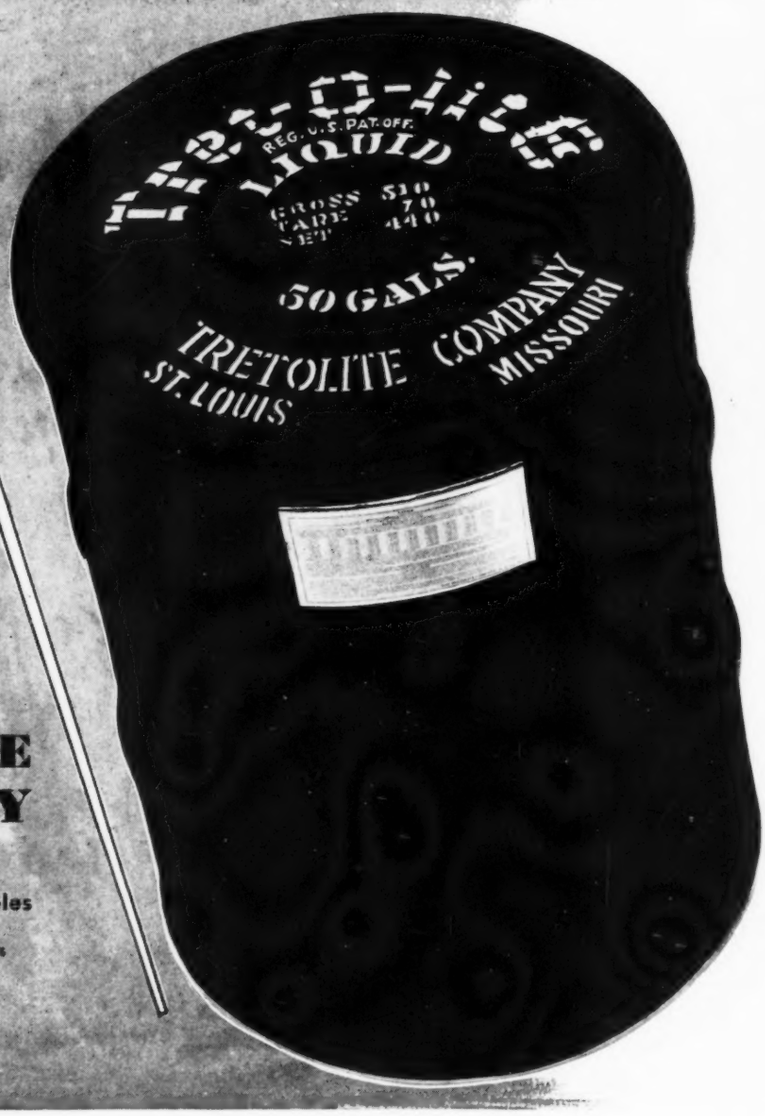

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THE Petroleum Engineer

FEBRUARY 1938

VOLUME IX NUMBER 5

A MAGAZINE OF METHODS FOR OPERATING MEN

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MEETINGS

California Natural Gasoline Association — March 3, Richfield Building, Los Angeles, California.

●

American Society for Testing Materials, Spring Regional Meeting and Group Committee Meetings—March 7, 8, 9, 10, 11, and 12, Seneca Hotel, Rochester, New York.

●

American Association of Petroleum Geologists, 23rd Annual Meeting—March 16, 17, and 18, Roosevelt Hotel, New Orleans, Louisiana.

●

American Society of Mechanical Engineers—March 23, 24, and 25, Los Angeles, California.

●

American Petroleum Institute, Division of Production, Southwestern District, Spring Meeting—March 24 and 25, Blackstone Hotel, Fort Worth, Texas.

●

Petroleum Industry Electrical Association—April 13, 14, and 15, Rice Hotel, Houston, Texas.

●

American Chemical Society—April 17, 18, 19, 20, and 21, Dallas, Texas.

●

American Petroleum Institute, Pacific Coast District, Division of Production, Spring Meeting—April 19, Biltmore Hotel, Los Angeles.

●

Western Petroleum Refiners Association, Annual Meeting—April 25, 26, and 27, Hot Springs, Arkansas.

●

American Petroleum Institute, Division of Production, Eastern District—April 28 and 29, William Penn Hotel, Pittsburgh, Pennsylvania.

●

Natural Gasoline Association of America, Annual Convention—May 11, 12, and 13, Hotel Tulsa, Tulsa, Oklahoma.

●

International Petroleum Exposition—May 14, 15, 16, 17, 18, 19, 20, and 21, Tulsa, Oklahoma.

●

American Petroleum Institute, Eighth Mid-Year Meeting — May 23, 24, and 25, Wichita, Kansas.

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The Course of Oil

By K. C. SCLATER

Nearing Pumping Stage Slowly but inevitably the East Texas field is approaching the stage when almost every producing well in the field will be on the pump. On all sides there is evidence that detrimental effects of the diminishing reservoir pressure are being felt. Already numerous wells have been equipped for pumping, on many others the work of equipping them is in progress, and on still others pumping needs are only now being anticipated or have not reached beyond the stage of preliminary planning.

There are indications that pumping methods in great variety will ultimately be used. The Railroad Commission has just granted permission for the use of hydraulic pumps in conjunction with the application of heat in wells. This permission was sought by those interested in the use of hydraulic pumps to make sure that there would be no conflict with the order of the Commission forbidding excessive heating of oil prior to gauging for proration purposes.

Another sign of the field's approaching senility is the increasing production of salt water, which has reached serious proportions in certain parts of the field. Aside from the cost of producing salt water, to dispose of it economically without causing pollution is an expensive undertaking that increases in magnitude with the age of the field. Two large operators have just been granted permission to experiment with underground disposal methods. One operator will attempt disposal by injection into the lower permeable zones of the Woodbine (the productive) sand. The injection well it is planned to experiment with will continue to produce gas and oil simultaneously with the injection of salt water. The other operator will experiment with the possibility of disposal by injection into the Paluxy sand.

Some wells in the field have had their flowing life extended. One major operator had the foresight several years ago to make plans in connection with its natural gasoline plant operations for flowing some 500 of its wells, using artificial gas-lift aids and residue gas. When this project was conceived it was a question of whether the cost of laying out a residue gas system for flowing this group of wells could be covered by the saving that would accrue by deferring the large expenditure in pumping equipment that would ultimately be required. How long the expenditure can be deferred of course will depend on how long the wells can be flowed profitably by gas-lift.

When the reservoir pressure reaches the point where the gas begins to come out of solution it is then that the real trouble and expense of producing oil in wells will be faced, and it will be then that the wisdom of conserving energy in the East Texas field by strict proration will become more apparent.

More Stringent Regulations Wild wells are by no means of rare occurrence and they are not confined to any one part of the country. Their frequency may be decreasing, but the fact that they occur as often as they still do, and in scattered areas, emphasizes the importance of taking precautionary measures while drilling.

How many blowouts might have been prevented will probably never be known. The enormous losses caused by them, it would seem, would be sufficient to deter operators from taking chances. Chances, however, are still taken. The Railroad Commission of Texas sensed this when they called a hearing on the Corpus Christi field to consider whether operators should be allowed to drill through 5½-in. casing to a deeper 5000-ft. sand. Commission engineers contend that this size casing is too small for safety, as it does not allow sufficient room with the drill pipe in the hole for mud fluid circulation for proper control in case of emergency. On this one point the Commission engineers are probably correct. In face of the many blowouts that have occurred, ample provision should be insisted upon for meeting this emergency. It is a contingency that all prudent operators make adequate provision to meet.

Stringent regulations, if it is the opinion of the Commission engineers that these are required, should be adopted. The damage resulting from one blowout might far exceed the extra expense of taking the necessary precautions suggested.

What Is a Gas Well? What is a gas well? Again this question is in dispute. A hearing has been called by the Texas Railroad Commission on whether a well that produces gas and condensate only is a gas well or an oil well.

In calling the hearing the Commission cites the fact that a Federal Court held that "oil is a liquid existing in the ground or reservoir as oil and as such is produced from it; the Commission finds that these highly volatile liquids may be in the gaseous state in the sand and that if this is true, these wells must be classified as gas wells." This basis of classifying gas wells is one that will need to be revised—at least so far as it applies to very deep wells.

It is fallacious to assume that "oil is a liquid existing in the ground or reservoir as oil." Scientific investigations indicate that in very deep wells the hydrocarbons may exist in the sand at a pressure and temperature above the critical, in which case the hydrocarbons would not be in the form of a liquid. Neither would they be in the gaseous form. They would probably be in a form that more nearly resembles a gas but would have properties more nearly resembling a liquid.

The court's method of classifying very deep wells is therefore inadequate. Classification should rest on what form the total hydrocarbons in the sand would exist under normal condition, that is, under standard conditions of temperature and pressure.

« « HIGHLIGHTS IN OILDOM » »

Michigan Operators Oppose Crude Price Reduction

Operators in the Buckeye field, Michigan, have agreed voluntarily to reduce their daily production to 20 bbl. per well in an effort to force higher prices of crude, which recently were cut 15 cents a barrel. By thus creating an artificial shortage it is hoped to restore the price to its former level. Approximately 80 percent of the operators in the field have voted in favor of the production cut.

The Buckeye field has a potential of approximately 96,000 bbl. per day and has been producing from 20,000 to 24,000 bbl. daily. The adoption of the production cut reduces the output to about 7000 bbl. daily.

●

Explains Illinois Well-Plugging Law

Attorney General Otto Kerner has issued a statement in which he explains the existing Illinois statute governing the plugging of wells when abandoning. Before casing shall be pulled, it is pointed out, the well must be plugged by filling it solidly from the bottom to a point 25 ft. above the oil-bearing zone. On top of this filling shall be seated a dry wooden plug and above the wooden plug the well shall be filled another 25 ft., above which shall be placed another wooden plug, the hole then being filled to the surface.

Kerner said further: "My information is that at the time the statute in regard to plugging oil wells was passed, rotary drills were not in use and the statute was framed with the thought that wells to be plugged would be drilled by churn drills. While it may not be possible to plug an abandoned oil well which has been drilled with a rotary drill in the precise manner provided by statute, still it occurs to me that such well must be so plugged that the effect thereon will be the same as the effect produced by the plugging of a well which has been drilled with a churn drill."

●

Russia Announces Rich Oil Discoveries

Discovery of rich oil deposits in far-eastern Siberia has been announced from Moscow. The discovery is described as of "colossal" national economic importance. The deposits are said to extend from Lake Baikal in central Siberia to the Pacific coast, approximately 1500 miles to the east.

●

Oil Antitrust Case to Be Reopened March 15

It will be March 15 before the next action in the oil antitrust case will be taken. On that date Judge Stone has indicated he will hear the motions filed by defense attorneys. The passing of sentence has been deferred pending disposition of the motions, the defendants being under personal bond.

Defense attorneys have asked for a new trial and the setting aside of the verdict that, on January 22, found 16 oil companies and 30 officials guilty of conspiracy to fix gasoline prices. As grounds for this request the defense claims there was no competent evidence presented showing that the defendants engaged in a conspiracy or committed an illegal act in the district where the trial was held; that there was a variance between allegations in the indictment and the proof; that the jury improperly considered matters not in evidence, and that the court erroneously stated the law in its charge to the jury.

Gas Proration In Rodessa Field, Texas

The Texas Railroad Commission issued an order early this month for the proration of gas in the Texas side of the Rodessa field. The plan of proration is the same as that in effect in the eastern part of the Panhandle field. These two fields are the only ones in the state where gas proration orders are in effect.

●

Kansas Stripper Areas Exempted From Proration

The State Corporation Commission has granted exemption from proration laws to operators in eight principal stripper counties of southeastern Kansas. The areas affected are the Erie and Chanute pools of Neosho County; all pools in eastern Wilson County; the Humboldt field in Allen County; all fields in Anderson, Greenwood, Bourbon, and Woodson counties, and all Butler County production except the McCullough pool. The granting of this exemption relieves operators of the necessity of filing monthly production reports.

In granting operators' requests for exemption the commission said it found wells in the areas "have an average production per well of substantially less than 15 bbl. daily, that pipe lines and other facilities are adequate for handling full production, and that full production can be had without committing waste.

"The question of the commission's power, in the prevention of waste, to limit production within pools even though there may be a market for the full production of the pool, is reserved for decision under facts and conditions in other cases as they arrive," the order stated.

Operators sought exemption from supervision and monthly production reports on grounds that the additional cost involved would force abandonment of many small wells.

●

Governors Study Means of Conserving Oil

The conference held at Hot Springs, Arkansas, January 25 by governors of oil states or their representatives had as its particular aim the conservation of petroleum reserves.

Governor E. W. Marland of Oklahoma, who called the conference, stated that it is his plan to have state geologists prepare reports on reserves and prospects for new discoveries. These reports will be presented at another conference to be held possibly in September, at which time it is proposed to draft model legislation. At the conference the possibility of 50-cent gasoline in the future was discussed. The difficulty of producing at least 25,000,000,000 bbl. of crude oil from new discoveries to meet the demand anticipated during the next 20 years was stressed.

At the next conference it is planned to have present technical men from the industry for the purpose of contributing information to aid the governors in determining what methods are most suitable to conserve the country's oil resources and to stimulate search for new fields.

●

Oil Reported Discovered Near Sansing, China

According to reports, oil has been discovered near Sansing, China, on the Sungari River below Harbin. The discovery is said to have been made by a survey party of the South Manchuria Railway, who stated the deposit consists of oil shale under which there is coal.

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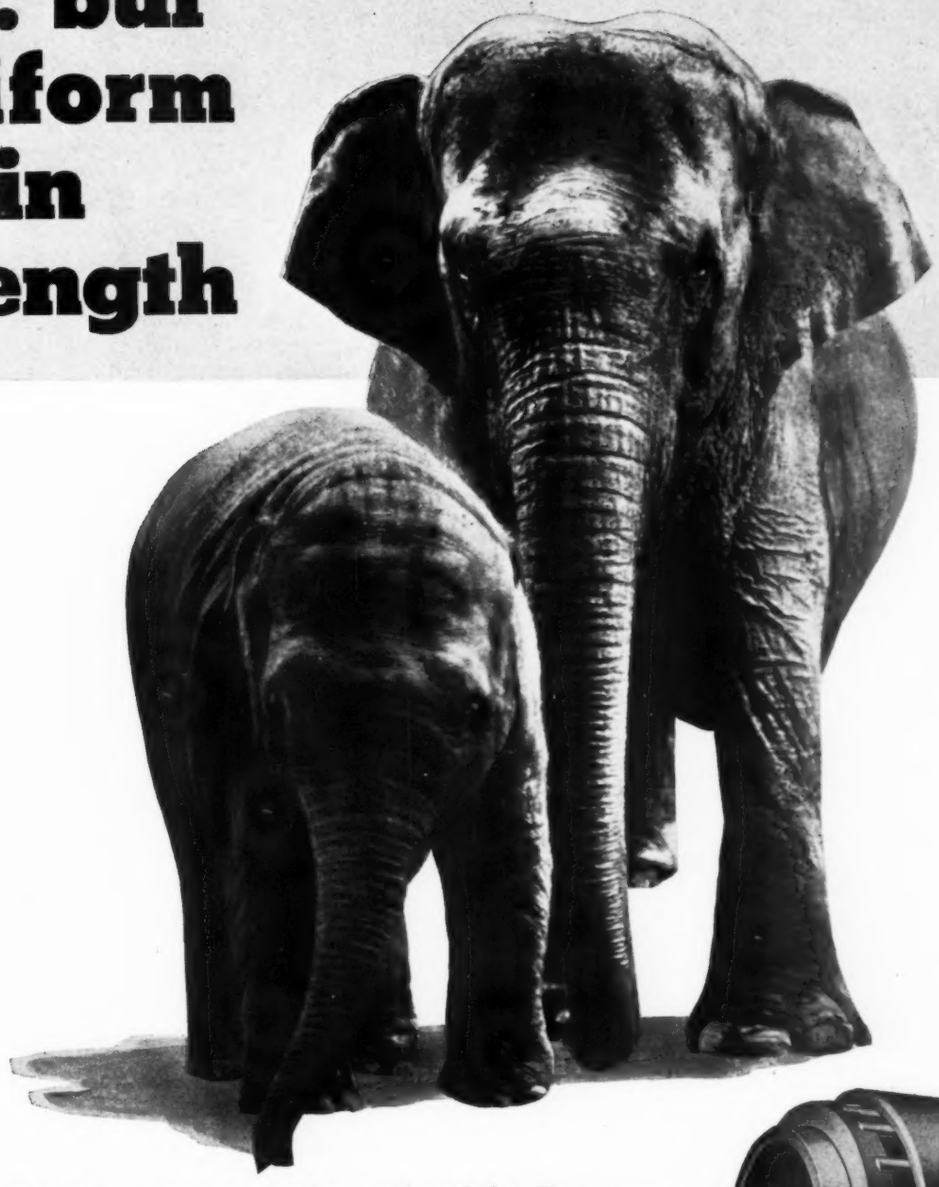

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Pennsylvania Producers Favor Conservation Law

Directors of the Central Pennsylvania Oil Producers' Association, representing 700 producers in Venango and adjoining counties, favor an oil conservation law for Pennsylvania, according to a recent vote. W. J. Brundred, vice-president of the association, and E. C. Breene, a director, have been named to draft such a bill, and they will appoint a third member of the committee. At the meeting at which this action was taken members of the board decided that if a special session of the Pennsylvania legislature is called the bill will be presented then, otherwise it will be brought up at the next regular session.

During the discussion of the need for a conservation measure Breene stated that if the Bradford field is allowed to become depleted before production in the lower fields is increased to replace it refiners of Pennsylvania crude may find themselves short of supplies.

Kansas Pools Allowed Increased Production

The State Corporation Commission has granted a minimum daily allowable of 25 bbl. per well to the following Kansas pools: Lorraine, Latta, Welch, Halstead, Raymond, Stoltenberg, Ritz, Greenwich, Ruder, Stratman, Voshell, Churchill-K. C., Eastborough, Edwards, Hollow Nikel, Oxford, Shutts, Burrton-Hunton, and Guldner. The increased allowable is permitted because of water encroachment that threatened premature abandonment of wells in the pools unless greater production were allowed.

Increase In Germany's Crude Oil Production

Crude oil production in the Hannover fields, Germany, during the first 11 months of 1937 totaled 2,639,056 bbl. compared with 2,596,027 bbl. during the corresponding period of 1936. This increase in production was attributable to greater output in the Nienhagen-Hänigsen fields, the other two areas, Wietze-Steinförde and Eddesse-Oberg, continuing to decline.

Production for all of Germany during November, 1937, amounted to 274,904 bbl. as compared with 265,650 bbl. during November, 1936, and 291,298 bbl. during October, 1937. For the first 11 months of 1937 total production in Germany was 2,894,359 bbl. as compared with 2,832,285 bbl. during the corresponding months of 1936, an increase of 62,074 barrels. These figures reveal that the Province of Hannover, as in the past, is the principal producer of crude oil, accounting for approximately for 91 percent of all production.

First Export Petroleum From French Morocco

Recently 7280 bbl. of crude petroleum was shipped from Port Lyautey, French Morocco, to Havre, France, attracting some interest as it was the first export ever to be made from that Protectorate. For several years the Protectorate Government has carried on a vigorous program of oil prospecting under the direction of its Bureau of Research and Mining Interests. Foreign geologists, who have visited the area, are of the opinion that there may be fair quantities of petroleum to the found in French Morocco.

The recent export shipment was from wells at Bou Draa and Tselfat, where approximately 980 bbl. of crude petroleum is being produced weekly. Production is too small to warrant the construction of a refinery to produce motor fuel for the purpose of competing with imports of petroleum products. Nevertheless, it should not be overlooked that the monopoly exercised by the Protectorate Government over its mineral resources and the efforts made by the French authorities to stimulate an interest in petroleum prospecting indicate that substantial development may be achieved, based principally upon financial assistance by the Metropolitan Government.

Favor Reduction Crude Oil Stocks

At a meeting in Oklahoma City, Oklahoma, recently, the executive committee of the Independent Petroleum Association of America urged reduction in crude allowables in order to reduce the above-ground stocks of crude petroleum to the level of January 1, 1937. It was voted to urge officials of all oil-producing states to restrict crude oil production in order to effect this reduction.

Five-Acre Spacing For Plummer Field

Following a Railroad Commission hearing a five-acre spacing plan appeared likely for the Plummer field, Bee County, Texas. All operators present at the hearing agreed upon the plan. The hearing was called by the commission, primarily to consider a casing program for the field, after a well with a short casing string blew out. An emergency order calling for 200 ft. of surface casing was instituted, and likely will be made a permanent order.

Oil Found In the Feroe Islands

Oil has been found in the Feroe Islands, according to a report from Thorshaven. The discovery was made by accident; during rock-blasting near Thorshaven oleiferous mud was found beneath a surface of clay and rock, the oil oozing to the surface through a crevice. Samples of the oil were sent to Denmark for analysis.

Texas Wells Shut in For Six Sundays

The first of six Sunday shutdowns, statewide in effect, was instituted January 23, by order of the Texas Railroad Commission. A limited number of wells were granted special permits that made it unnecessary for them to be shut down on Sundays but required their regular allowable to be curtailed one-seventh. The Sunday shutdown order will reduce production in the state during the six-weeks' period a minimum of 8,431,440 barrels.

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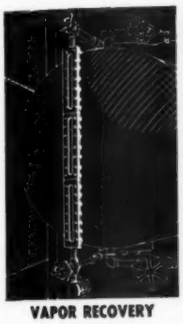

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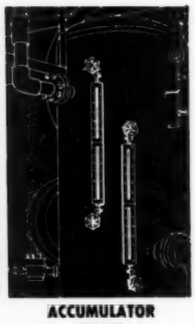
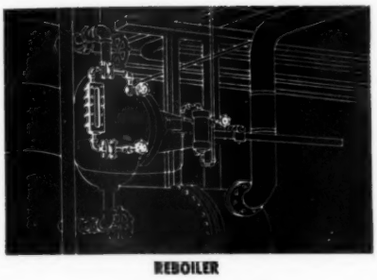


ACCUMULATOR TANK



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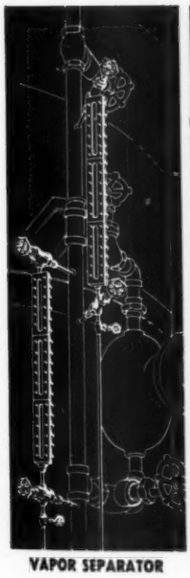

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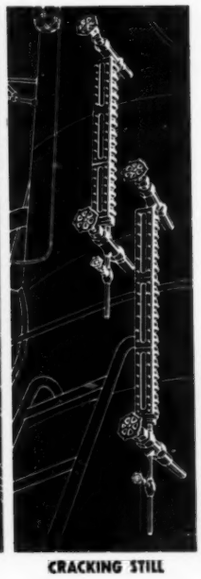
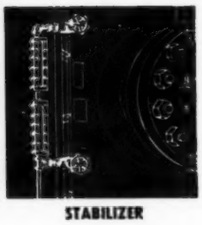


CRACKING STILL



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Latest Activities In The Oil Fields

THE Standard Oil Company's Kern County Land No. 15-1 in section 27, 30-26, more than a mile east of the nearest producing well in the Ten Section field, California, flowed 285 bbl. of 27.5-gravity oil daily when completed by swabbing through perforated liner set on the plug at a depth of 8075 feet. The well was cored to a depth of 8140 ft. and plugged back. The 7-in. casing is set and cemented at 8000 feet. This is the first important discovery of the year for the San Joaquin Valley area.

●

Extending its Evangeline Parish, Louisiana, production by more than two-thirds of a mile and proving up approximately 1500 acres, the Continental Oil Company has completed its No. 1 Central Land and Development Company near Ville Platte. During the initial 24-hour test the well produced 430 bbl. of 41.6-gravity crude through 3/16-in. choke. The tubing pressure was 1600 lb. and the casing pressure 1700 pounds. Although the well was drilled to a total depth of 9085 ft., production is from a 59-ft. zone in the Sparta formation from 9017-76 feet.

●

Northwest of Cisco in Eastland County, Texas, the Lone Star Gas Company's No. 1 Cozart flowed at the rate of 288 bbl. per day during the Railroad Commission's gauge of potential. Production was obtained from the Ellenburger limestone between 3946 ft. and 3971 ft. after treating with 1000 gal. of acid. This is the second producing well in this recently-discovered field.

●

A new well in the old Mahannah pool, the first in 20 years, has revived interest in that part of Cowley County, Kansas. J. A. Green et al's No. 3 Mahannah in NWC SW 6-30-8w, seven miles southeast of Latham, pumped 792 bbl. of 42-gravity oil in a 16-hr. test. Production is obtained from the first break in the Mississippi lime. Total depth of the well is 2825 feet.

In northern Wyoming the Garland Syndicate No. 1 Government produced sweet gas at the rate of 2,230,000 cu. ft. per day by official gauge when completed in the Torchlight sand. Total depth of the well is 2047 ft., the production string being set at 1963 feet. The well was first drilled in 1926 but a decision of the state supreme court forced the abandonment and removal of the carbon-black plant that was the only outlet for the gas, so the well was plugged. The present well was completed by whipstocking out of the old hole at 1535 feet. The present operators plan to extract casinghead gasoline from the gas and then return the gas to the sand.

●

The Union Producing Company's No. 1 Simmonds, two and one-half miles northeast of the Agua Dulce field, Nueces County, Texas, was completed through perforated casing at 4810-4835 feet. The well was drilled to 8710 ft. and plugged back. Closed-in pressure is 1950 pounds. It has not been determined whether this well extends the Agua Dulce field or opens a new pool.

●

The Lisbon field, Claiborne and Lincoln parishes, Louisiana, has been extended three-fourths of a mile southwestward by the completion of C. R. Shuster's No. 1 Sallie Lloyd. This well, drilled in SWC of 2-20-5w, flowed ten bbl. an hour through 10/64-in. choke; casing pressure was 700 lb., and tubing pressure 75 pounds. This is the first major extension of this field in several months.

●

Dobbs Oil Company's No. 1 Hodges, drilled east of Sipe Springs, Comanche County, Texas, produced 50 bbl. of oil in an hour and twenty minutes. Initial production rate was 400 bbl. in six hours. All available storage has been filled. Flowing pressure is 500 lb., shut-in pressure 650 pounds. Casing is set on top of the Marble Falls limestone at a depth of 2525 ft. and total depth of the well is 2710 feet. The lime was treated with 4000 gal. of acid.

AVERAGE CRUDE PRICES

California	
Kettleman Hills	$1.19-1.43
Playa Del Rey	.80-1.16
Coalinga	.70- .90
Signal Hill	.80-1.21
Montana	1.35
Wyoming	.97-1.30
Colorado	1.12-1.18
New Mexico	.78-1.08
Texas	
North Central	.96-1.20
Panhandle	.91-1.08
West Texas	.78-1.08
Gulf Coast	.95-1.41
Darst Creek	1.09
East Texas	1.35
Talco	.73
Kansas	.98-1.30
Oklahoma	.98-1.30
Arkansas	.90
Louisiana	
Rodessa	$ .91-1.25
Gulf Coast	.84-1.41
North Louisiana	.90-1.22
Illinois	1.35
Kentucky	1.40
Indiana	1.12
Ohio	
Lima	1.25
Michigan	1.27
Pennsylvania	
Bradford	2.20
Southwest	1.88
Eureka	1.82
Buckeye	1.70
Corning	1.27
West Virginia	1.67
Canada	2.10-2.17

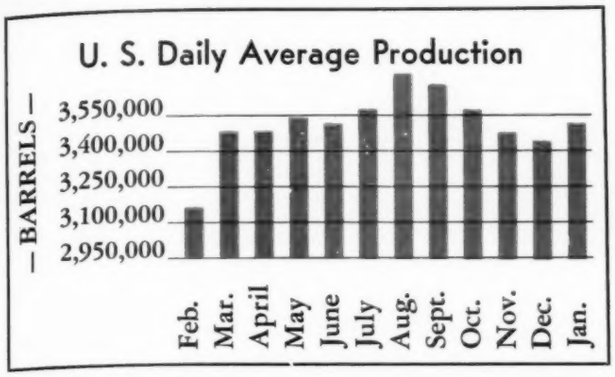
DAILY AVERAGE CRUDE OIL PRODUCTION

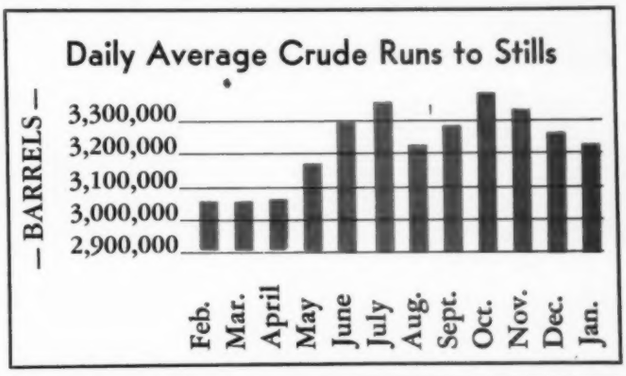
Data Supplied by A.P.I.

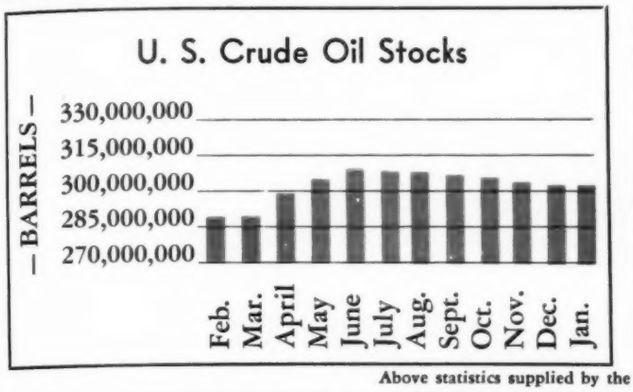
(Figures in Barrels)

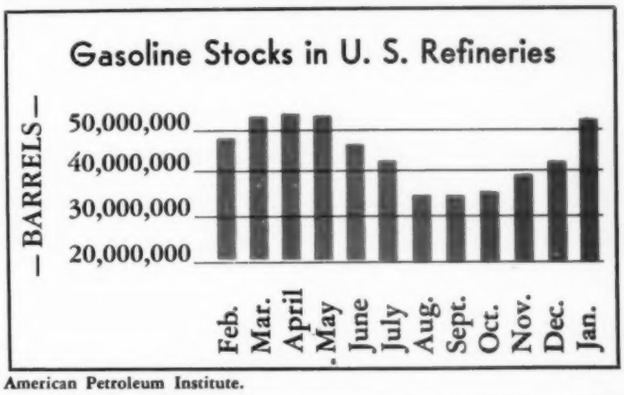
	B. of M. Dept. of Int. Calculations (January)	Week Ended Jan. 29, 1938	Week Ended Jan. 1, 1938	Week Ended Jan. 30, 1937
Oklahoma	566,600	553,900	533,700	587,750
Kansas	179,300	187,050	166,600	173,600
Panhandle Texas		74,200	67,450	74,800
North Texas		63,000	73,500	65,600
West Central Texas		31,350	32,700	32,700
West Texas		175,600	194,250	171,200
East Central Texas		79,250	85,800	105,950
East Texas		423,250	491,200	449,350
Southwest Texas		206,900	237,250	187,550
Coastal Texas		184,250	196,750	180,950
TOTAL TEXAS	1,350,900	1,237,800	1,378,900	1,268,100
North Louisiana		78,450	76,400	86,350
Coastal Louisiana		176,200	174,650	165,150
TOTAL LA.	238,400	254,650	251,050	251,500
Arkansas	35,200	42,450	48,800	23,050
Eastern	128,000	132,750	131,750	116,000
Michigan	54,100	48,250	50,100	29,000
Wyoming	55,500	50,800	48,100	48,800
Montana	13,100	13,450	13,750	16,450
Colorado	4,300	4,200	4,400	3,550
New Mexico	103,100	107,150	107,750	92,850
TOTAL EAST OF CALIF.	2,728,500	2,632,450	2,734,900	2,610,650
California	678,300	725,200	701,700	583,400
TOTAL U. S.	3,406,800	3,357,650	3,436,600	3,194,050

Summary of Petroleum Statistics and Field Activities









Above statistics supplied by the American Petroleum Institute.

Summarized Operations in Active Fields for January, 1938

Fields	Completions	Producers	Rigs	Drilling Wells	Depth of Production	No. Casing Strings	Gravity of Oil	Type of Tool Used
TEXAS								
East Texas	217	210	42	99	3500-3700	2	40	Rotary
Duval County	39	29	8	33	1554-2900	2	22	Rotary
Ector County	60	60	12	71	3675-4377	2 and 3	32-36	Rot.-Cab.
Panhandle	67	67	57	173	1700-3900	2	40	Rotary
Refugio County	12	10	2	13	4900-5900	2	38	Rotary
Nueces County	21	16	11	47	3922-5878	2 or 3	21-54	Rotary
Winkler County	27	27	8	16	2850-3450	2 and 3	30-38	Rot.-Cab.
Talco Field	21	21	2	11	4230-4361	2	16-24	Rotary
K. M. A.	33	32	70	104	3730-3935	2	42-43	Rot.-Cab.
OKLAHOMA								
Oklahoma City	3	3	1	3	6450-6682	3	39	Rotary
Fitts Pool	22	18	3	13	1800-4488	2 or 3	38	Rotary
KANSAS								
Russell County	30	25	10	46	2926-3435	2 and 5	32-37	Rot.-Cab.
Rice County	14	14	6	26	3222-4085	2 and 5	42-48	Rot.-Cab.
Barton County	36	29	7	38	3290-3518	2	39-42	Rot.-Cab.
LOUISIANA-TEXAS-ARKANSAS								
Rodessa	28	28	7	28	5950-6450	3	39	Rotary
ILLINOIS								
Central Illinois	42	34	29	103	2950-4100	2	36-38	Rot.-Cab.
NEW MEXICO								
Lea County	44	41	14	108	3150-4030	3	30-34	Rot.-Cab.
CALIFORNIA								
Kettleman Hills	2	2	1	13	8300-8730	3 or 4	40	Rotary
Wilmington	23	23	23	32	3500-4000	2 and 3	18-20	Rotary

Field Activities by States for January, 1938

State	Completions		Producers		Locations		Rigs		Drilling Wells		Production, 1937 (In Barrels)
	January	December	January	December	January	December	January	December	January	December	
Arkansas	18	22	17	17	22	10	16	17	31	46	12,088,341
California	90	101	71	82	133	136	107	109	259	251	238,587,663
Colorado	2	1	0	0	....	....	1	2	30	32	1,532,893
Illinois	62	61	34	37	....	14	118	120*	36	34	7,376,022
Indiana	....	24	....	17	....	....	3	3	34	31	820,000
Kansas	170	195	130	133	175	159	48	59	331	339	70,542,000
Kentucky	46	83	29	59	....	....	13	14	84	88	5,500,000
Louisiana	115	67	74	42	92	80	39	47	199	219	90,501,068
Michigan	54	67	40	45	58	67	43	44	159	162	16,254,181
Mississippi	....	2	....	0	....	....	8	2	12	14	Gas Prod.
Montana	3	9	1	7	....	....	2	3	49	55	5,775,000
New Mexico	44	44	41	41	....	....	15	18	155	160	38,642,184
New York	3	7	3	6	....	....	....	....	....	....	5,466,200
Ohio	80	125	53	77	....	....	53	57	192	196	3,547,600
Oklahoma	172	205	129	142	185	187	52	49	352	377	225,402,731
Pennsylvania	....	....	....	....	....	....	....	....	....	....	19,154,400
Texas	996	1183	801	966	1152	1535	352	387	1399	1462	506,891,233
West Virginia	81	88	66	72	....	....	33	30	168	201	3,833,000
Wyoming	7	11	7	7	....	....	10	12	78	68	19,402,121
Total	1943	2295	1496	1750	1817	2188	913	973	3568	3735	1,271,316,637

*Including 80 rigs standing and 40 rigging up.

Progress of Major Pipe Line Work

ENGINEERS of the Channel Gas Corporation are working on specifications for a 14-in. pipe line from Houston, Texas, to the Bammel field, 20 miles to the north. It is planned to have the line in operation by May 15.

The laying of this line will provide Houston with another natural gas supply for industrial consumers. Officials of the Channel Gas Corporation announce the signing of a contract for the entire gas output of the Bammel field, which has an estimated reserve of 318,000,000,000 cu. feet. The contract was made with Hamill and Smith, independent operators of Houston, who have most of the acreage in the area.

The capacity of the new line will be approximately 75,000,000 cu. ft. per day.

The Channel Gas Corporation was granted a franchise by the city council of Houston about six months ago to supply natural gas to industrial consumers.

Officers of the company are: H. C. Cockburn, president; R. E. Smith, vice-president; Claude Hamill, treasurer; Mrs. Hortense Ward, secretary; W. H. Ward, general counsel; and L. C. Doney, chief engineer.

●

A third unit installed at the Noble Station of the Wabash Pipe Line Company increases the capacity of the line by 8000 bbl. daily, making it now approximately 32,000 barrels. The line connects the Clay-Richland-Wayne County area of Illinois to a trunk line at Martinsville. The Wabash Pipe Line Company is a subsidiary of the Pure Oil Company and the original line was completed in October, 1937.

●

A recent press dispatch from Casper, Wyoming, quotes J. Kirk Baldwin, state treasurer, as discussing a plan for piping natural gas from Wyoming to northern Colorado and Denver. Mention was made of a proposal to have the North Central Gas Company extend its line from Wheatland to Cheyenne, thence through northern Colorado to Denver. That company's gas supply is obtained from the Big Sand Draw and Muskrat fields in Fremont County, Wyoming.

●

Two new compressor stations were completed at Oakland and Ventura, Iowa, recently by the Northern Natural Gas Company. The stations are on the trunk line of the company extending from Skellytown in the Texas Panhandle to Minneapolis and St. Paul, Minnesota. Increased consumer demand, particularly in Minnesota, necessitated the construction of the stations.

At the Oakland station two 900-hp. twin-tandem, double-acting units were installed, provision being made for the installation of a third unit when needed. Two 150-hp. auxiliary generating units to provide electricity for the plant also were provided. The capacity of the station is 90,000,000 cu. ft. daily.

At Ventura three 800-hp. units were installed, together with auxiliary equipment similar to that at Oakland.

The Northern Natural Gas Company now has nine compressor stations on its trunk line, having a total of 37,800 horsepower.

A 50-year franchise has been obtained by Sam G. Harrison, Houston, Texas, for the laying of lines and mains for natural gas service in Waller County, Texas. The project will involve the laying of approximately 25 miles of 4-in. and 5-in. pipe line; construction is expected to start within the year. Gas will be transported to the towns of Katy and Brookshire and to nearby industrial plants. The gas supply will be obtained from the Katy field between Katy and Brookshire.

●

The Magnolia Pipe Line Company will erect a booster station one mile south of Orange Grove, Texas, on its crude oil line from Tilden, McMullen County, to Corpus Christi. A site was purchased recently and work has begun.

●

The Shell Pipe Line Company has announced plans for the laying of a 4-in. pipe line from the Jennings field, Arcadia Parish, Louisiana, to connect with its Lake Charles to Iowa-Roanoke line. The Jennings field is only a few miles from the company's main line. The United States War Department has been asked for permission to cross Bayou Nespique, a navigable stream.

●

The Oklahoma Pipe Line Company is laying approximately 21 miles of 8-in. line from Ardmore, Oklahoma, north. The line is being oxy-acetylene welded by the Lindeweld method.

●

The Cities Service Gas Company has completed the construction of an 8-in. line from its Oklahoma City 20-in. trunk line to the Harrah, Oklahoma, electric plant of the Oklahoma Gas and Electric Company. The company also is adding a 170-hp., twin-cylinder engine to the equipment in its Wellington compressor station near Wellington, Kansas, increasing the total hp. of the station to 490.

●

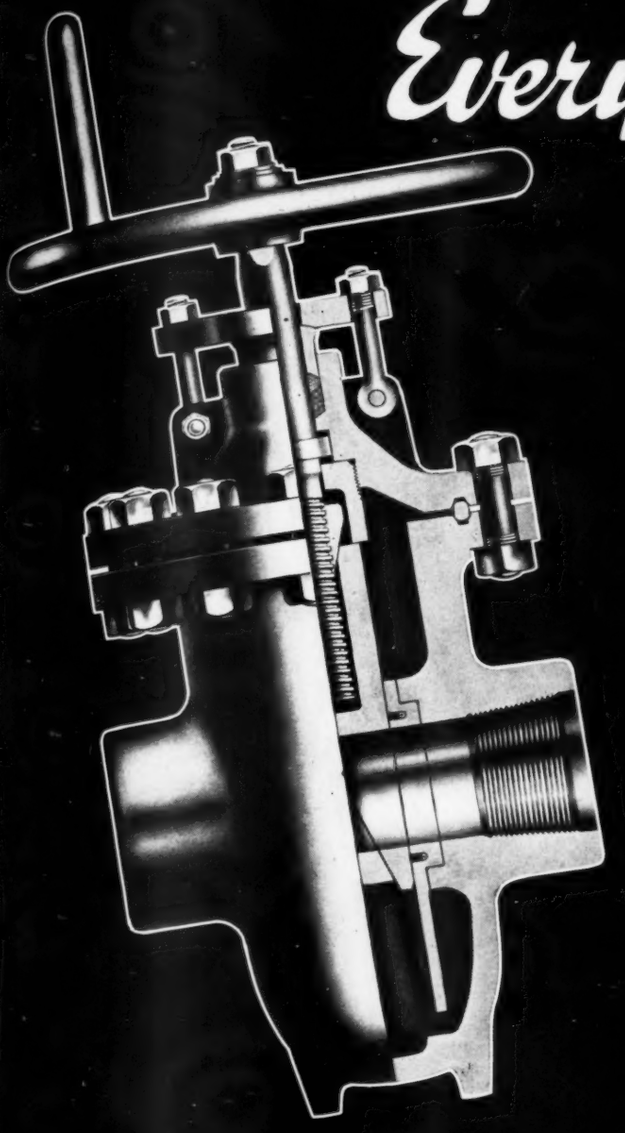
The Gulf Pipe Line Company is acquiring right-of-way paralleling its line from Jenks, Oklahoma, to points in Ohio. Officials of the company state that there is no intention of laying any new line at the present time, and possibly not in the immediate future. Right-of-way is being procured in a gradual manner in order that it may be ready at such time as the company feels the need for increasing the capacity of its line.

The Gulf Pipe Line Company line, a 10-in. system, was constructed in 1930 and initially had a daily capacity of 32,000 bbl., pumping stations being 55 miles apart. In 1936 the line was "looped" with 10-in pipe, increasing the capacity to 42,500 bbl. per day.

●

Gordon F. Van Eenenaam, a director of the Commonwealth Pipe Line Company, Holland, Michigan, has announced the purchase by his company of crude oil gathering lines of the Imperial Refining Company of Grand Rapids. This gives Commonwealth connections with 45 producing wells in the Salem Township field. Construction of a pipe line either to Holland or Muskegon is contemplated, it is stated.

Every Working Part
MOVES IN A BATH OF GREASE



It's easy to see why the W-K-M Through-Conduit Lubricated Gate Valve whips the outstanding evil of valves . . . friction and corrosion. This valve body is itself a grease chamber, and every moving part is wholly submerged in a grease bath. The gate and segment are thoroughly lubricated at each operation. This means complete freedom from internal corrosion, and a minimum of friction. By the same token it means easy opening and closing at full rated pressure. Positive lubrication like this is one of the valuable features making it by far the most popular gate valve on the market.

THE 3" W-K-M GATE VALVE HOLDS THIS SIX LBS. OF GREASE

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OIL FIELD · PIPE-LINE & INDUSTRIAL EQUIPMENT
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COSTS NO MORE THAN ORDINARY VALVES
Sold Through Supply Stores Everywhere

Aluminum Paint on Oil-Field Boilers

By R. F. LARSON[1]

THE use of aluminum paint is recognized as an effective means of reducing fluctuation in temperature in the vapor space of oil storage tanks, thereby reducing evaporation losses incident to vessels that must be vented to the atmosphere. This method of controlling radiation or absorption, and thereby controlling heat transfer, until recently had not been used to any great extent in other fields, and in some instances has not been recognized as being applicable and practicable.

To review briefly the accepted heat transfer theory: heat is transferred from a source or hot body to a receiver or colder body in three ways; conduction, convection, and radiation. All three may take place simultaneously. Convection is limited to an intervening medium that will flow, i.e., to liquids or gases. Conduction takes place in solids, liquids, or gases, or from one to another. It is supposed to take place as a transfer of kinetic energy from molecule to molecule, or from particle to particle, much as motion and energy are transferred from one billiard ball to another.

The capacity to conduct heat differs for different substances even of the same class; however, it is usually greatest in the denser solids, less in the liquids although there are some exceptions, and least in gases. Transfer of heat by conduction is somewhat analogous to diffusion.

Convection is the process by which parts of the medium are carried about either by natural currents set up by differences in density, or by artificial means. Convection, then, is limited to liquids and gases, and may be regarded as an adjunct to conduction of heat in a fluid by its function of mixing, whereby steeper temperature gradients or greater temperature differences are maintained. Heat transfer in liquids or gases, or between solids and liquids or gases, ordinarily would be small were it not for convection. This principle is recognized in the design of boilers and heat exchangers.

Conversely, low heat transfer or insulating effect can be attained by preventing convection, relying upon the low thermal conductivities of the materials to restrict heat transfer. The common commercial insulation owes its insulating value principally to the stagnant air space or voids that it contains.

Heat transfer by radiation takes place most efficiently in the absence of an intermediate medium; however, gases do not interfere greatly. All the heat received by the earth and its atmosphere from the sun is transmitted by radiation. This energy can be reflected by a suitable surface in the same manner as light; however, total reflection usually is not possible, a portion being absorbed by the surface. Absorption of radiant heat results in warming of the absorbing surface. The insulating value of aluminum paint is due to its high reflecting capacity, and hence its low absorbing capacity.

The same relations are true for a body or surface at a temperature greater than its surroundings and from which radiation takes place. The capacity for radiation is again governed by the nature of the surface. The dark, dull, rough, or oxidized surface, known to be a good absorber of the sun's radiation, is also the best radiator of heat, whereas the good reflecting surface is the poorest radiator.

According to the Stefan-Boltzmann Law the factors that govern the amount of radiation or heat loss are the extent of the radiating surface exposed and effective, the absolute temperature of the radiating and receiving surfaces, and the emissivity of these surfaces. Emissivity is merely a measure of the radiating capacity of the surface, and is equal to the absorbing capacity of that surface for radiant heat. All surfaces reflect some radiant heat, but the idealized surface called a "black body" would be one that absorbed all the radiant heat that fell upon it. Dark, dull, and rough surfaces approach the properties of the "black body" and hence have emissivities approaching unity, the emissivity of the "black body." From the standpoint of insulating value the surfaces used should be such that they absorb and emit but little radiant heat. Light-colored, smooth, shiny, and polished surfaces are examples of this type.

All bodies or surfaces radiate heat or energy in proportion to the fourth power of their absolute temperature, hence radiation becomes increasingly large at high temperatures. Furthermore, the gain or loss of heat or energy by radiation for the body considered will be the difference between the heat or energy that it radiates, and that which it receives and absorbs from the surrounding bodies.

The character of the low temperature or "receiving" surface of the oil tank exposed to solar radiation is controlled so as to limit absorption. The high temperature or "radiating" surface of the exposed oil-field boiler can be similarly controlled, in this case to limit emission.

The total external heat loss from a 100-hp. oil-field boiler operating at 300-lb. pressure in still air at 60 deg. fahr. is on the order of 15 horsepower. A conservative calculation of the radiation loss from this boiler is about nine hp. of which seven or eight hp. could be saved by coating the boiler with a heat-resisting aluminum paint having a reflective index of .85*. This radiation loss and its proportion of the total heat loss in still air would be even greater in cold weather, and hence an even greater saving could be effected. Similar saving or reduction in condensation loss could be expected if exposed steam lines, separators, engines, and pumps were similarly painted.

If the boilers are housed, the use of aluminum paint on both the boilers and the housing will further reduce heat loss and keep the enclosure warmer.

If blanket insulation or removable jackets of the conventional type are not practicable because of cost or damage when equipment must be moved frequently, the use of aluminum paint or similar material appears to be an economical way of insulating.

---

*Calculation of radiation loss for 100-hp. boiler.

Stefan-Boltzmann Law:

$$Q=\frac{1723\ A}{\frac{1}{e_1}+\frac{1}{e_2}-1}\left[\left(\frac{T_1}{1000}\right)^4-\left(\frac{T_2}{1000}\right)^4\right]$$

Q = heat radiated, B.t.u. per hour.

e_1 = emissivity of hot surface, taken as .95 for boiler.

e_2 = emissivity of cold surface, taken as .85 for air, sky, and surrounding surfaces. For clear sky e_2 is almost 1.0.

A = radiating area of boiler, taken as 380 sq. feet.

T_1 = abs. temp. of hot surface, taken as 880° F. (460 + 420).

T_2 = abs. temp. of cold surface, taken as 520° F. (460 + 60).

From above,

Q = 280,000 B.t.u./hr. = 8.64 boiler hp.

If

e_1 = .15 (assumed for aluminum paint).

Q = 49,100 B.t.u./hr.

280,000—49,100=230,900 B.t.u./hr. = 7.3 boiler hp. saved.

[1]Assistant professor of mechanical engineering, University of Illinois.

. . . it's the best of its kind!

Production crews have been quick to appreciate that any tool marked BJ is easy to handle, fast in operation, and so safe that they have no worries even on the deepest wells.

BJ Surestop Tubing Catchers (see left) are the last word in protecting your tubing while RUNNING-IN, or COMING OUT of the hole or while SUSPENDED IN THE WELL. With the optional BJ Anchoring Method the catcher can be set at any desired point thus eliminating "tubing breathing" and enabling the stationary pump to operate efficiently.

The BJ "10" Rod Hook (above) is recommended for use on shallow wells. Its operating and safety features can be enjoyed at nominal cost; made also in a size to handle 15 tons of rods.

The enclosed relief spring in the BJ "20" Rod Hook (left above) prevents burring threads when extremely long, heavy strings are carried, but the overall length has been held to a minimum.

The "Locking Arm" on all BJ Tubing Hooks not only positively retains the elevator bail, but forms a C-link which adds greatly to the safe load capacity.

The "30" (far left) is for use in short derricks; the "50" and "75" are equipped with enclosed relief springs.

Where tubing strings are of average length, and costs must be low, the BJ Shortype "C" Tubing Catcher (right) is "first choice" for positive tubing safety.

Have you seen the new BJ Catalog? It's in the 1938 Composite Catalog, starting on Page 446, or we have a separate copy awaiting your request.

Ask your supply store to show you the 1938 Model BJ Rod Elevators—and other successful tools, which will help get the job done quickly, safely and economically!

BYRON JACKSON CO.

FORT WORTH • LOS ANGELES • NEW YORK

BJ PRODUCTION TOOLS

The Month's Activities in Refining

Percent Refinery Capacity Operated

Western Division, 70.5 Percent **Central Division, 73.6 Percent** **Eastern Division, 81.3 Percent**

THE Sun Oil Company announces it will spend $11,000,000 during 1938 expanding and developing its refineries. The program was adopted at a recent meeting of the board of directors. The refineries involved are at Marcus Hook, Pennsylvania, and Toledo, Ohio. The program will increase the capacity of the plants as well as adapting them to new refining processes. The latter will make possible greater recoveries from the crude and also an improved finished product, at the same time reducing the cost of refining, J. Howard Pew, president of the company, states.

•

Gas and Oil Products, Ltd., plans to double the capacity of its skimming plant at Hartell, Alberta, Canada, it is announced by A. H. Maynard, president of the company. Existing capacity is 500 bbl. daily. Consideration also is being given to the construction of a 1000-bbl. skimming plant in the South Turner Valley field.

•

The Park Refining Company's 2000-bbl. skimming plant at Cody, Wyoming, has been sold to the Husky Refining Company, recently organized. The new owners plan to add a cracking unit to the plant, increasing gasoline production.

•

The Humble Oil and Refining Company has completed and placed in operation its new gasoline plant in the Flour Bluff field, Nueces County, Texas. The capacity of the plant is 20,000,000 cu. ft. of gas daily, and the output of gasoline 10,000 to 12,000 gallons.

•

Construction of the Southwestern Oil and Refining Company's 5000-bbl. skimming plant at Lake Charles, Louisiana, has begun. It is situated on the deep-water ship channel at that point. The company's engineering department is doing the construction work under the supervision of I. B. Chittenden, chief engineer. The refinery is expected to be completed by the middle of May.

The Eggleston Oil Products Company has completed its refinery at Three Rivers, Live Oak County, Texas. The skimming unit of the refinery has a daily capacity of 3000 bbl., and the vacuum unit a capacity of 1500 bbl. daily.

•

The Richfield Oil Corporation announces plans for completely modernizing the crude distillation unit at its Watson, California, refinery. The improvements contemplated will, when completed, make it unnecessary to rerun the oil, as is done at present, to manufacture a complete group of products. Capacity of the unit will be 14,000 to 19,000 bbl. of crude daily, depending upon the type of crude being run. C. F. Braun and Company, Inc., have been awarded the contract for the work.

•

The Warren Petroleum Company's new natural gasoline plant in the McCampbell field, near Aransas Pass, Texas, will be placed in operation this month. The capacity of the plant will be 50,000,000 cu. ft. of gas daily, recovering approximately 25,000 gal. of gasoline.

•

The Colonial Beacon Oil Company, Inc., Everett, Massachusetts, has under way the construction of a combination unit that will more than double the capacity of the existing plant, which has a crude capacity of 24,000 bbl. daily and a cracking capacity of 19,000 barrels. The plant's treating system also will be modernized.

•

H. R. Harriman, John Laing, and associates, operating as the Garland Syndicate, plan to erect a natural gasoline plant in the Garland field, northern Wyoming. A large-producing gas well was completed recently in the shallow Torchlight sand, prompting the decision to construct the gasoline plant. Additional wells will be drilled by the company, it is stated.

Crude Runs to Stills, Gasoline and Gas and Fuel Oil Stocks
Week Ended January 29, 1938

A.P.I. Figures

(Figures in Barrels of 42 Gal. Each)

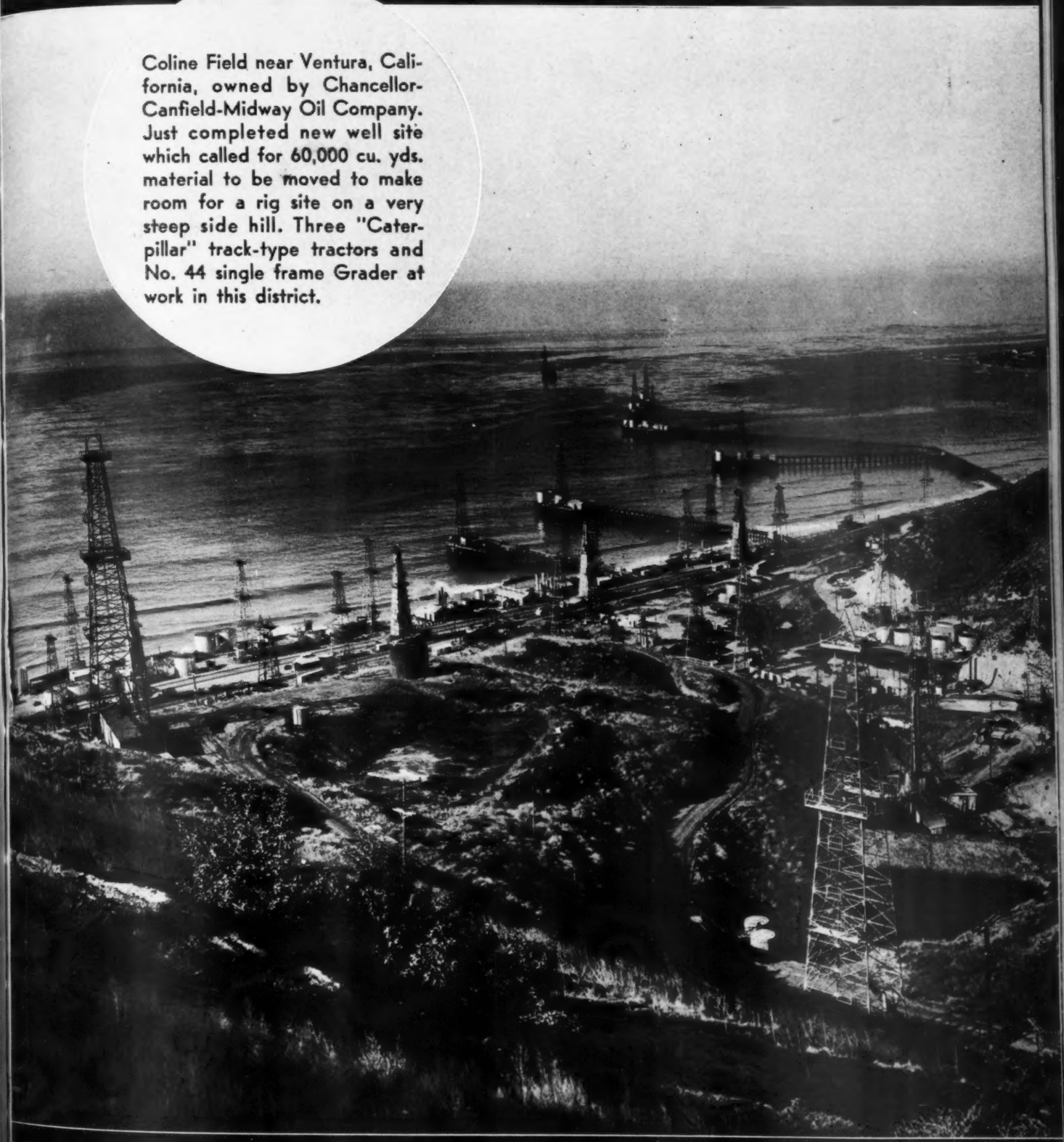
DISTRICT	Percent Potential Capacity Reporting	Daily Avg. Crude Runs to Stills	Percent Operated of Total Capacity Reporting	Total Motor Fuel Stocks Thousands of Bbl.	Gas and Fuel Oil Stocks Thousands of Bbl.
East Coast	100.0	489,000	73.1	20,029	11,446
Appalachian	88.4	112,000	86.8	3,334	1,216
Ind., Ill., Ky.	92.4	411,000	84.0	13,959	6,771
Okla., Kans., Mo.	84.7	263,000	68.7	7,183	3,551
Inland Texas	56.6	119,000	59.2	2,574	1,659
Texas Gulf	95.7	732,000	91.8	12,732	10.487
La. Gulf	96.6	136,000	81.0	2,526	3,281
No. La.-Ark.	63.7	39,000	67.2	507	471
Rocky Mt.	69.7	45,000	72.6	1,924	691
California	90.9	510,000	68.4	15,186	76,430
Reported	89.0	2,856,000	77.1	79,954	116,003
Est'd Unreported	.....	314,000	.....	4,890	2,790
*EST'D TOTAL U.S. Jan. 29, '38	.....	3,170,000	.....	84,844	118,793
*EST'D TOTAL U.S. Jan. 22, '38	.....	3,220,000	.....	82,785	118,433
U.S. B. of M. *Jan. 29, 1937	.....	**3,038,000	.....	70,878	102,664

*Estimated Bureau of Mines' basis.

**January, 1937, daily average.

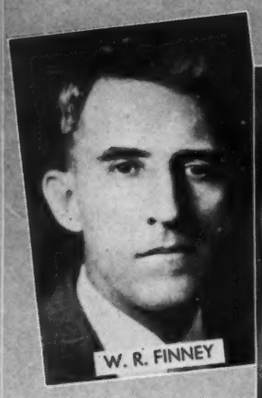
PICTORIAL PETROLEUM

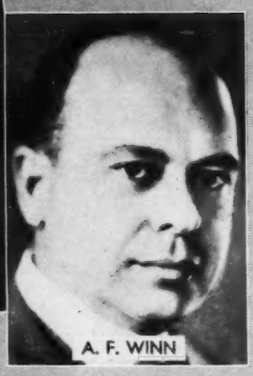
Coline Field near Ventura, California, owned by Chancellor-Canfield-Midway Oil Company. Just completed new well site which called for 60,000 cu. yds. material to be moved to make room for a rig site on a very steep side hill. Three "Caterpillar" track-type tractors and No. 44 single frame Grader at work in this district.



A REGULAR MONTHLY FEATURE OF "THE PETROLEUM ENGINEER" *February*

THESE MEN PLAN FOR THE 50% LARGER INTERNATIONAL PETROLEUM EXPOSITION AT TULSA MAY 14 TO 21


W. R. FINNEY


A. F. WINN

EXECUTIVE COMMITTEE

C. F. CAMP

COMMITTEE CHAIRMEN—INTERNATIONAL PETROLEUM EXPOSITION

W. R. Finney, president of the Oklahoma Pipe Line Co., Tulsa, pipe line committee.

A. F. Winn, traffic manager Skelly Oil Co., Tulsa, the transportation committee.

Executive committee (left to right) H. R. Powers, Bethlehem Supply Corporation of Tulsa, secretary; Alf G. Heggem, president Oil Well Improvements Co., Tulsa, vice-president; W. G. Skelly, president, Skelly Oil Co., Tulsa, president; C. H. Pape, secretary and treasurer of the Selby Oil and Gas Co., Tulsa, treasurer; Frank O. Prior, president of the Stanolind Oil and Gas Co., Tulsa, director; W. M. Bovaird, president, Bovaird Supply Co., Tulsa, director; Wm. B. Way, general manager and Frank J. Hinderliter, president Hinderliter Tool Co., Tulsa, vice-president. Earl Sneed, Sneed Royalty Corp., Tulsa, housing bureau; H. M. Cosgrove, executive secretary of the Purchasing Agents Association of Tulsa, chairman, purchasing agents committee; James H. Gardner, president, Gardner Petroleum Corp., Tulsa, chairman of the Foreign Delegates committee; J. A. LaFortune, vice-president, Warren Petroleum Corp., Tulsa, chairman of the natural gasoline committee; C. F. Camp, secretary and treasurer, Arrow Drilling Co., Tulsa, drilling contractors committee; H. R. Gruber, vice-pres. in charge of oil country sales for the Union Wire Rope Corp., Tulsa, chairman, "old timers" committee; J. D. McCamey, director of safety, Carter Oil Co., Tulsa, safety day committee; Dr. Gustav Egloff, director of research, Universal Oil Products Co., of Chicago, chairman, scientific and technical committee of the Exposition; Luther H. White, chairman of the Exploration committee of the Exposition, manager of the land and geological department of the Deep Rock Oil Corp. of Tulsa; R. W. McDowell, vice-president, Mid-Continent Petroleum Corp., Tulsa, chairman, marketing committee; D. E. Buchanan, president, Hanlon-Buchanan, Inc., Tulsa, chairman, local entertainment and host committee; H. M. Stalcup, vice-president of the Skelly Oil Co., Tulsa, chairman, production committee.

EARL SNEED

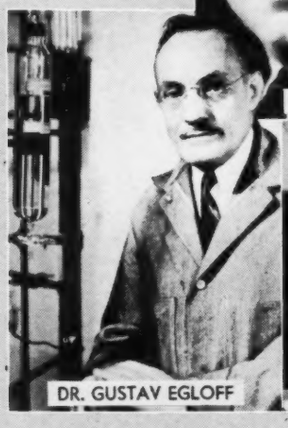
H. M. COSGROVE

H. R. GRUBER

J. D. McCAMEY

JAMES H. GARDNER

J. A. LaFORTUNE


DR. GUSTAV EGLOFF

LUTHER WHITE

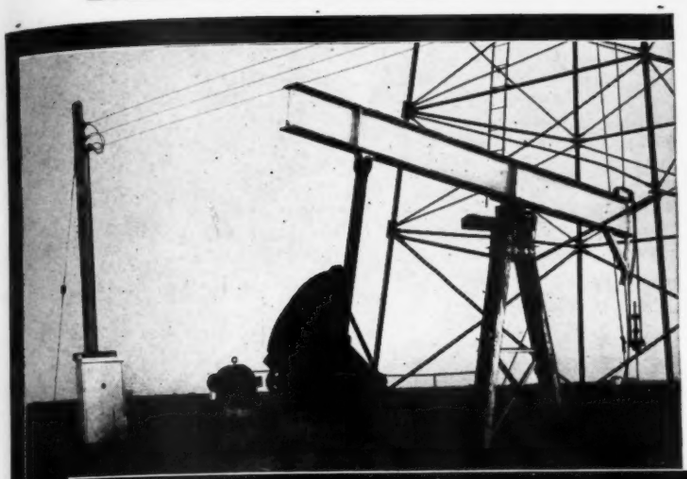
R. W. McDOWELL

D. E. BUCHANAN

H. M. STALCUP

GET YOUR ALLOWABLE

FOR ONLY 2 TO 3¢ PER BARREL!



By actual performance over a long period of time, Electrically Powered Prime Movers have proved unusually efficient and economical—the average deep well lifting cost being from 2c to 3c per barrel of oil.

Not only the lifting cost has been reduced in nearly every instance, but allowables are obtained with a certainty. Think what this means in extra profits!

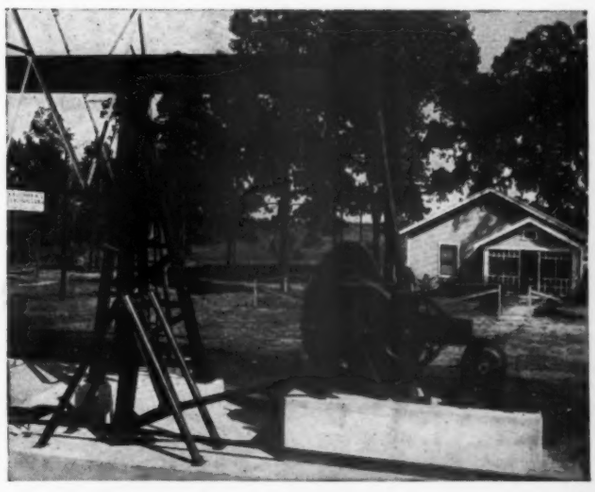
Too, fixed charges such as taxes, interest, insurance, depreciation, etc., are lower when you use Purchased Electric Power. This modern, low cost power is available to you. Just ask your nearest Electric Power Company for facts concerning your power problems!

PROFITS BY USING Purchased ELECTRIC POWER

Typical Beam Pumping Installations

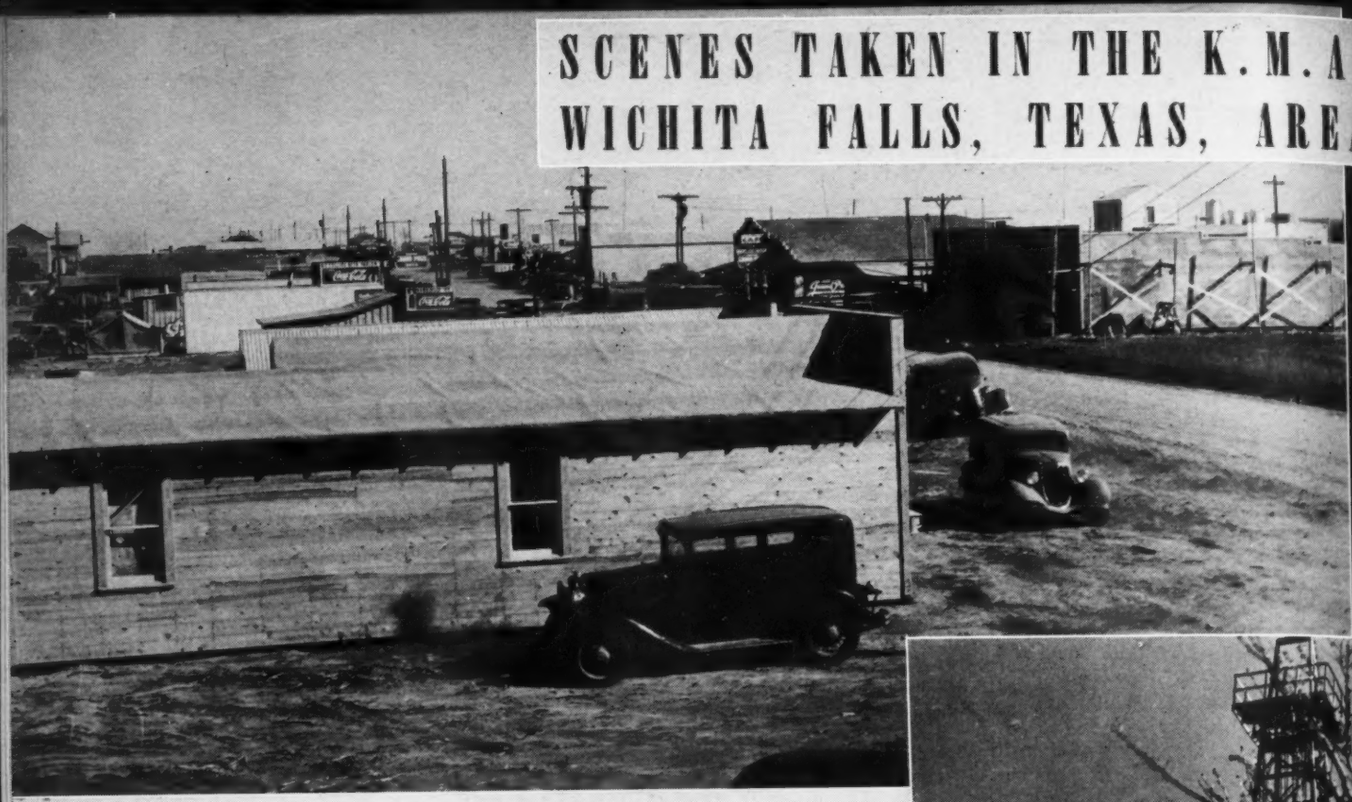
(Above and at the right)

Weatherproof type motors are con'inuously on the job. They are ready and without notice or unnecessary loss of time will start production. No delays due to low temperature, all the power you need at the time you need it ... none going to waste. Note the low installation cost.

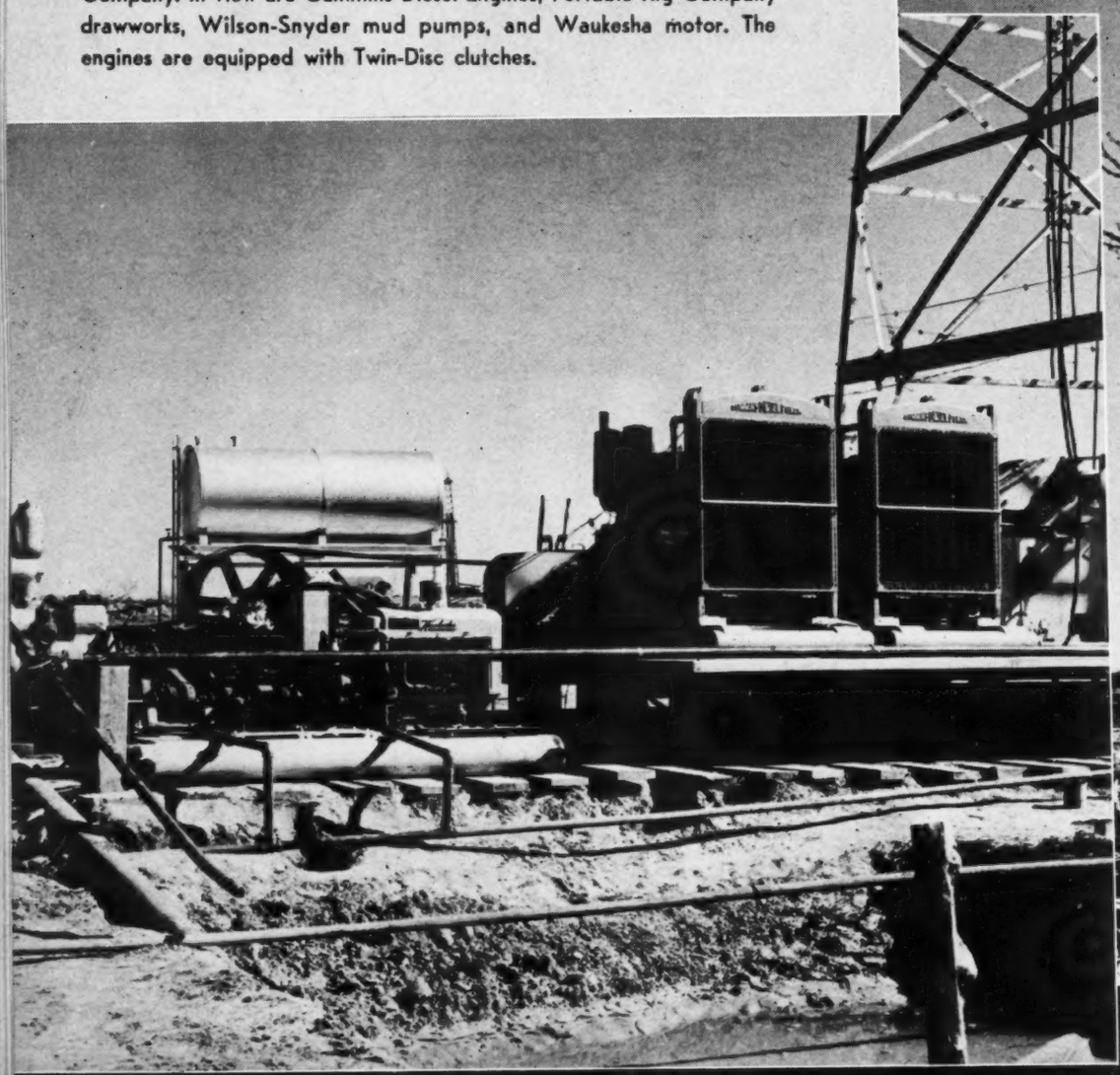


PETROLEUM ELECTRIC POWER CLUB

SCENES TAKEN IN THE K.M.A. WICHITA FALLS, TEXAS, AREA



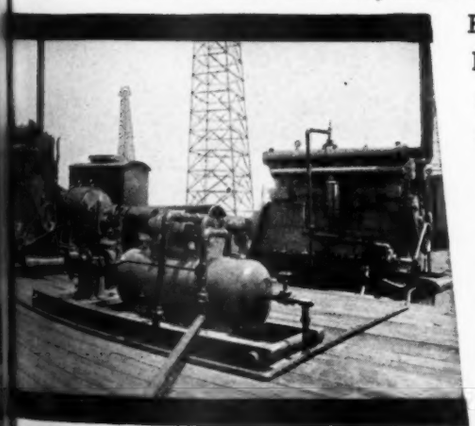
Right: Cook Drilling Company's Kemp No. 1 well on which the equipment is all new. Above: Street view of Kemp City. A majority of these buildings have been erected within the past six weeks. Below: Close-up of some of the equipment on the Kemp No. 1 well of Cook Drilling Company. In view are Cummins Diesel Engines, Portable Rig Company drawworks, Wilson-Snyder mud pumps, and Waukesha motor. The engines are equipped with Twin-Disc clutches.



BLACK GOLD!

The right rig for the particular conditions in your territory means greater safety and efficiency every time. Unbiased recommendations as to which type of rig will serve you best provides the surest, quickest road to bigger profits.

Allis-Chalmers can make such unbiased recommendations because they make all three—the All-Electric Rig . . . the Electrical-Mechanical Rig . . . and the Texrope Drive Mechanical Rig.



The All-Electric Rig, shown on this page, is especially adapted to deep wells in difficult formations and to locations where excessive gas is a hazard. Internal combustion engines—which may be as far removed from the well as safety demands—supply mechanical power which is transformed into electrical power. This is transmitted by cable to the motors on the rig. Very ample ratings of generators and motors make this rig capable of handling the toughest job. Individual speed control on all motors provides smooth starting and acceleration.

An Allis-Chalmers rig drilled the deepest hole in Oklahoma—over 11,000 feet. Allis-Chalmers rigs are now drilling the deepest holes ever contemplated in the Gulf Coast area.

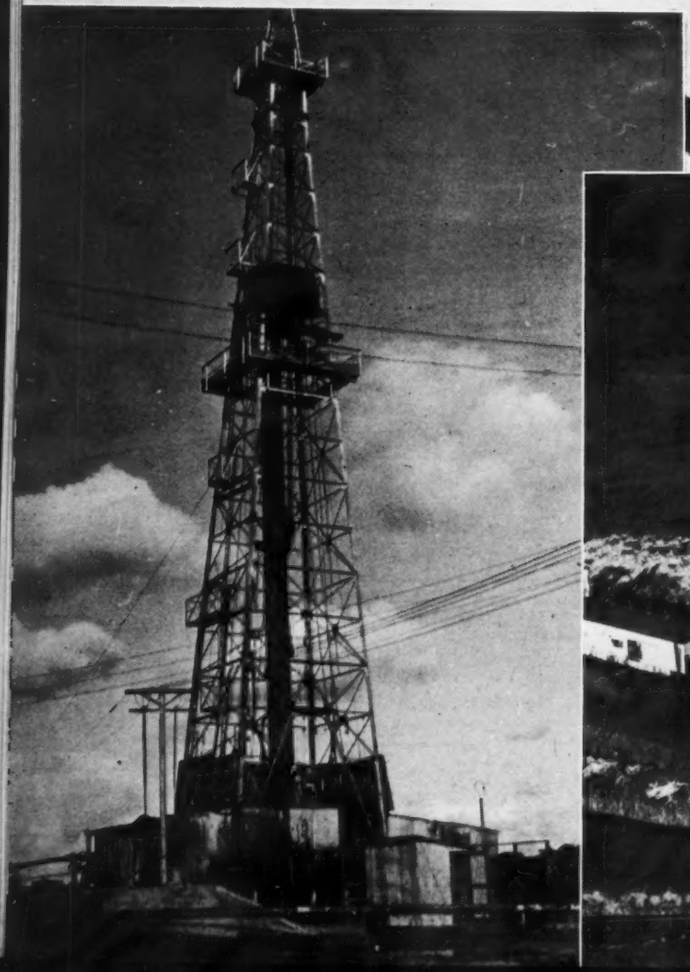
If you want the speed and economy of the most up-to-date rigs on the market send today for illustrated bulletin No. 163 which gives you full information on all three types. 859

MILWAUKEE WISCONSIN

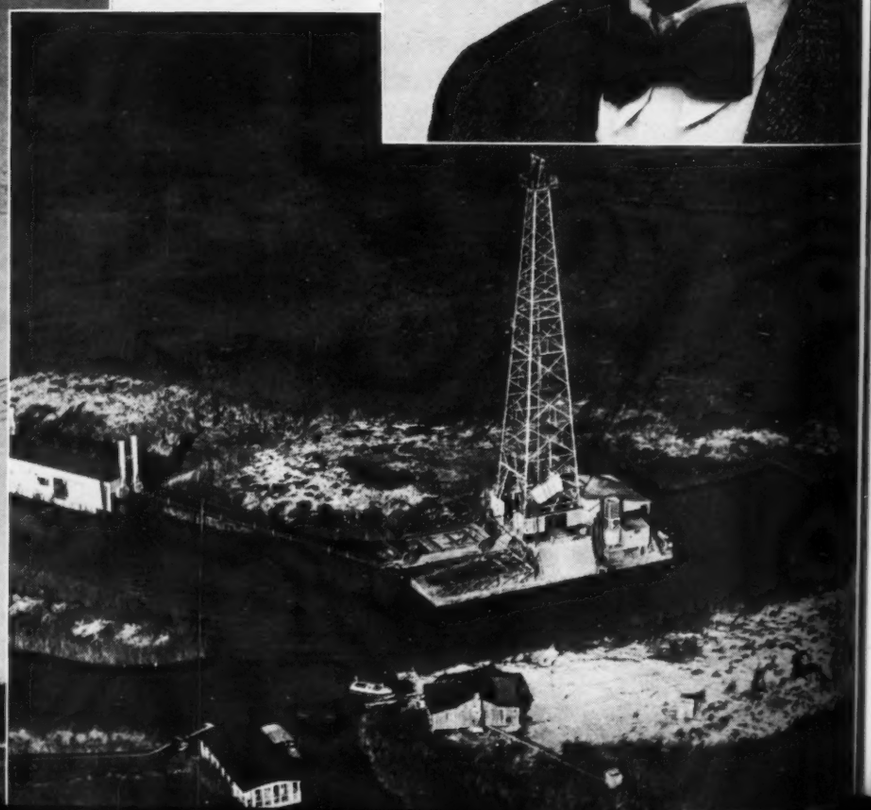
Above: Photograph taken at a dinner recently tendered by Colonel W. F. Rockwell, president, to some 80 officers and heads of departments of Pittsburgh Equitable Meter Company and Merco Nordstrom Valve Company.

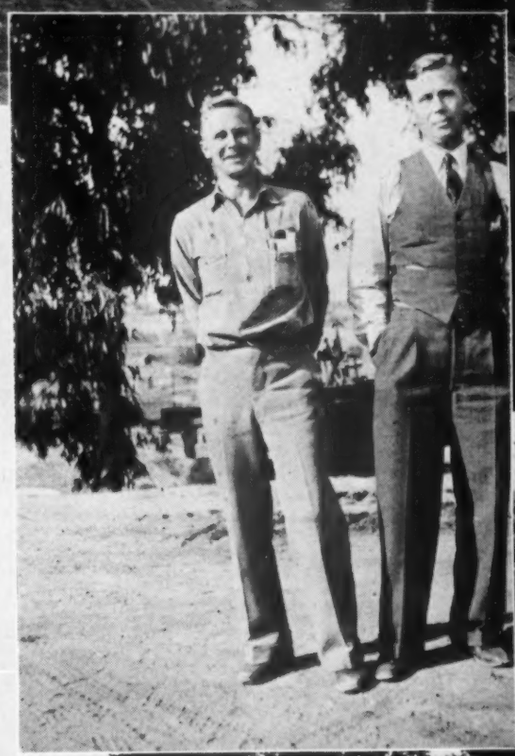
Right: E. A. Clarke of the sales and advertising department of Hughes Tool Company, Houston, Texas.

Below, Left: Continental Oil Company's A-2 well near Wasco, California, on which a new world's record for drilling depth has recently been set. Latest reports give the depth as 13,085 feet. After setting the usual 500 feet of surface casing (16-in. 65-lb. casing) 5512 ft. of 10¾-in. casing was set, which operation required 1000 sacks of cement. In November the crew set the world's longest string of casing at 11,570 feet. This was 7-in. I.D.



Below, Right: Close-up aerial view of a well of The Texas Company at Lafitte, Louisiana. It is planned to drill this well to a depth of 15,000 feet.



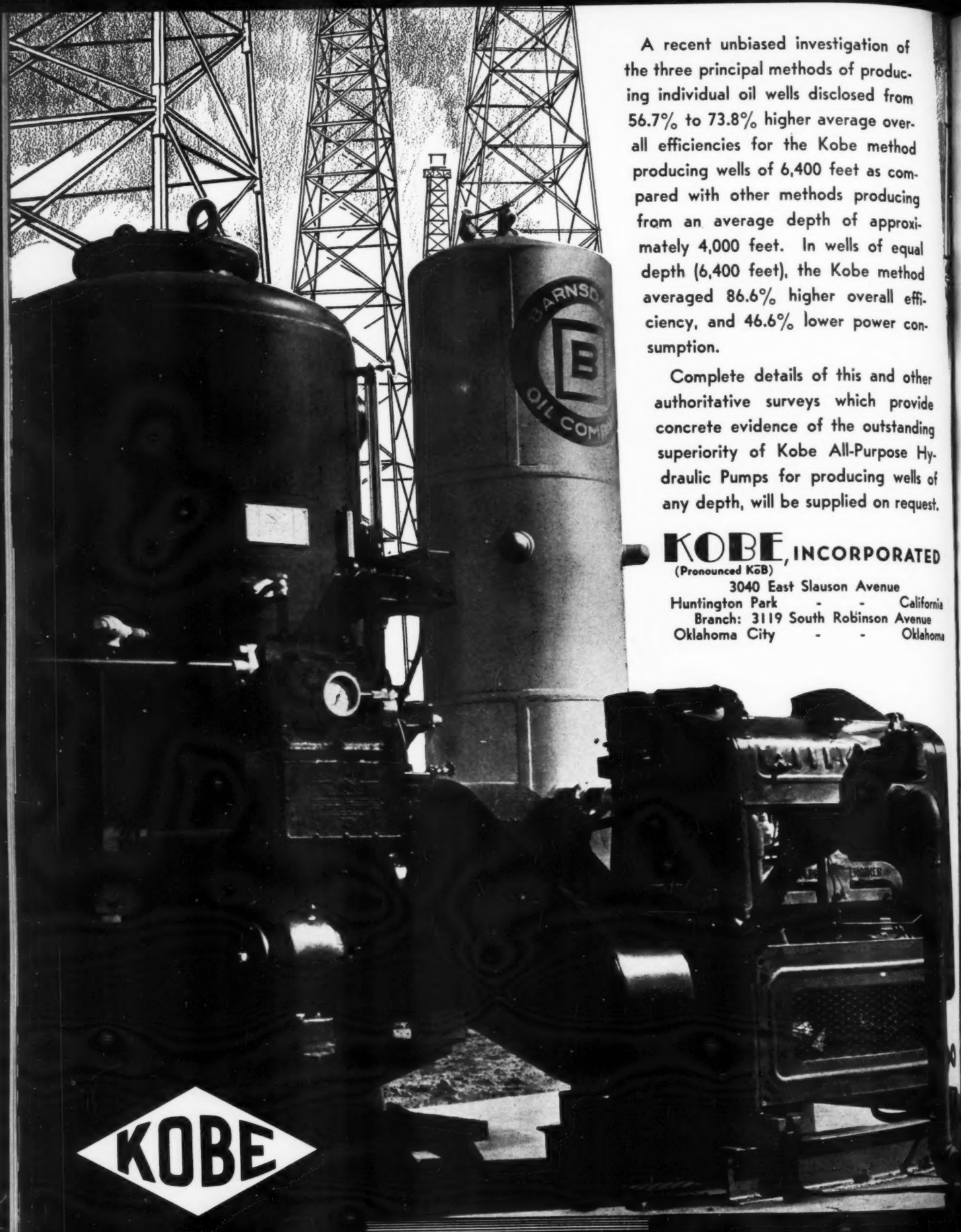


Above: Banquet held the latter part of December by Houston Oilfield Materials Company, Houston, Texas, for executives and members of the sales and clerical forces.

Right: Snapshot taken in the Signal Hill Field of J. H. "Abe" Abramson (left), production superintendent for A. T. Jergins Trust, and G. W. "Waldo" Moore, California sales manager for the Cavins Co.

Below, Left: Chicago Bridge & Iron Company recently fabricated these x-rayed and stress-relieved welded refinery vessels at their Birmingham, Alabama, plant. The order called for 14 vessels, five of which will be installed at North Baton Rouge, Louisiana, and the remainder in Venezuela.

Below, Right: International Harvester Company's T-20 TracTracTor handling pipe for a paint gang. This photograph was taken of the 8-in. gasoline line built for transportation affiliates of Atlantic Refining Company from Williamsport, Penna., to Buffalo, New York, with lateral extending north to Rochester. Jones & Hanrahan, pipe line contractors of Dallas, Texas, built this 220-mile line.



A recent unbiased investigation of the three principal methods of producing individual oil wells disclosed from 56.7% to 73.8% higher average overall efficiencies for the Kobe method producing wells of 6,400 feet as compared with other methods producing from an average depth of approximately 4,000 feet. In wells of equal depth (6,400 feet), the Kobe method averaged 86.6% higher overall efficiency, and 46.6% lower power consumption.

Complete details of this and other authoritative surveys which provide concrete evidence of the outstanding superiority of Kobe All-Purpose Hydraulic Pumps for producing wells of any depth, will be supplied on request.

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THE Petroleum Engineer

FEBRUARY, 1938

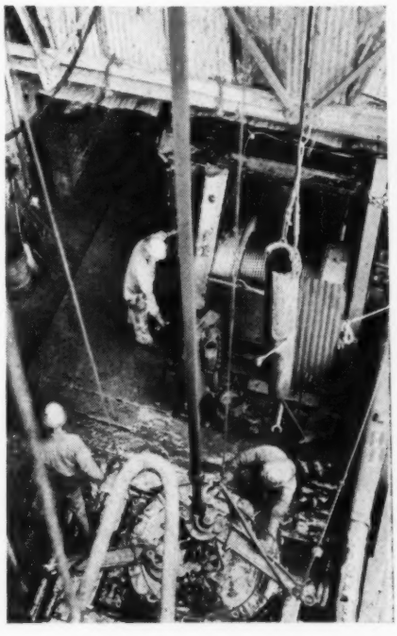
A New Depth Record

Well in the San Joaquin Valley drilled beyond 13,000 ft. to exceed the previous world record

By WALLACE A. SAWDON
Petroleum Engineer, Los Angeles

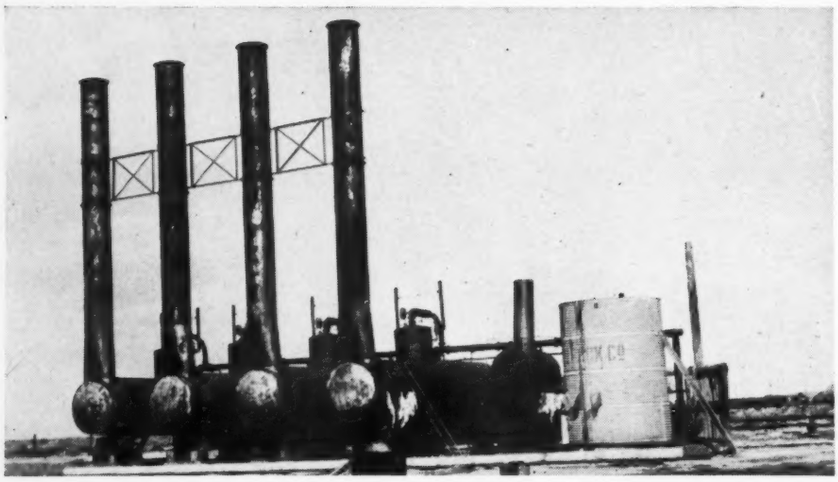
THERE seems to be a good prospect of obtaining commercial production in Continental Oil Company's K.C.L. No. A-2, which had reached a depth of 13,154 ft. on February 11, 1938. This well is in section 8-27-24, approximately five miles west of Wasco, California, and about 17 miles northwest of the Union Oil Co. K.C.L. No. 1-34 that opened the Rio Bravo field in a producing sand that is now the deepest in the world.

The Continental well is strictly a wildcat and it is the second drilled in this immediate area. The first was drilled to a depth of 9591 ft. and had a non-commercial showing of oil. This was not considered a conclusive test of the area, but the well was not drilled deeper because of mechanical difficulties. The present well was located 660 ft. farther north and it was spudded in on June 25, 1937. Including two months spent on a fishing job, only 217 days total elapsed time was required to reach the depth of 12,786 ft., where the previous world depth record, held by the Gulf Oil Corporation's McElroy 103, was passed on January 27, 1938.



Breaking out a tool joint in drill pipe

No special equipment has been used in drilling this well and this fact reemphasizes that equipment now available is adequate for drilling to depths now contemplated if modern drilling technique is combined with intelligent planning by the management and coöperation between the field and technical personnel. In this well, as in every outstanding drilling achievement, record applications of equipment were made and modifications of equipment to meet the demand of such applications were designed.



The boiler plant consists of four 250-lb., 100-hp. boilers and a separately-fired superheater

A string of 16-in., 65-lb. surface casing was set at 497 feet. Badly heaving shales were drilled to a depth of 5500 feet. The extreme difficulty encountered in passing through this formation in the first well was largely avoided by the addition of silicate of soda to the mud to seal off the walls. High-pressure gas necessitated the use of mud weighing more than 100 lb. per cu. foot. A string of 10¾-in., 55.8-lb. casing was cemented at a depth of 5512 ft. to case off this troublesome formation.

Drilling then continued, using rock bits on 4-in. internal-flush, external-upset drill pipe. At 11,580 ft. a massive sand body was encountered, and the drill pipe stuck. The pipe was cut with inside cutters, washed over, and recovered.

A string of 7-in., 30-lb. extreme line casing was then run and cemented with high-temperature cement at a depth of 11,573 feet. The temperatures encountered in this well probably are lower than the temperature gradient would indicate for this area, but no measurements were made.

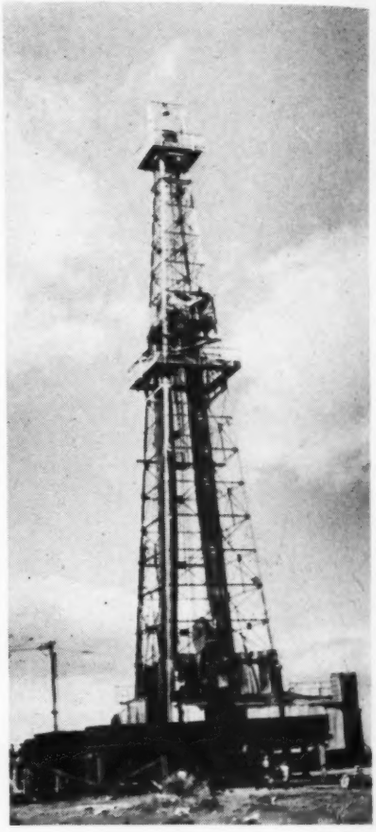
The 7-in. casing is the longest string of any size that has been run in a California well and its length is exceeded only by that of an 11,795-ft. string of 5-in. and a 12,097-ft. string of 7-in. casing run in wells in southern Louisiana. This casing was equipped with a float shoe and was run into the well in eight and one-half hours at a maximum rate of 1790 ft. an hour. A formation tester was used to make the water-shut-off test after cementing the 7-in. casing; this stuck and had to be fished.

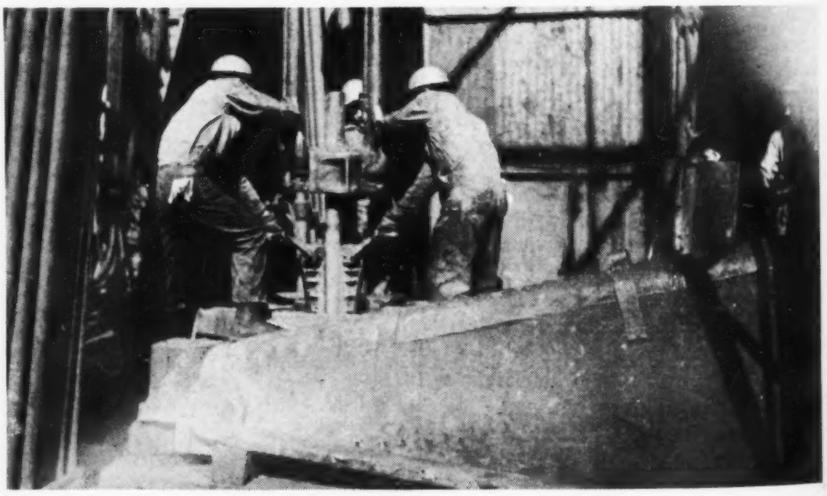
The time spent fishing, running casing, cementing and waiting for the cement to set, and testing the sand (which proved non-productive) required 68 days. Drilling then continued, using 6-in. bits on 3½-in. internal-flush, external-upset drill pipe having a step-thread joint and circulating fluid weighing 69 lb. per cu. foot. The fluid is made of water and admixtures and its weight is carefully controlled.

The well-head is protected with control equipment, which includes a blow-out preventer and two cellar control gates. One gate is full-opening and the 7-in. cock was made to order. It is the first of this size ever made.

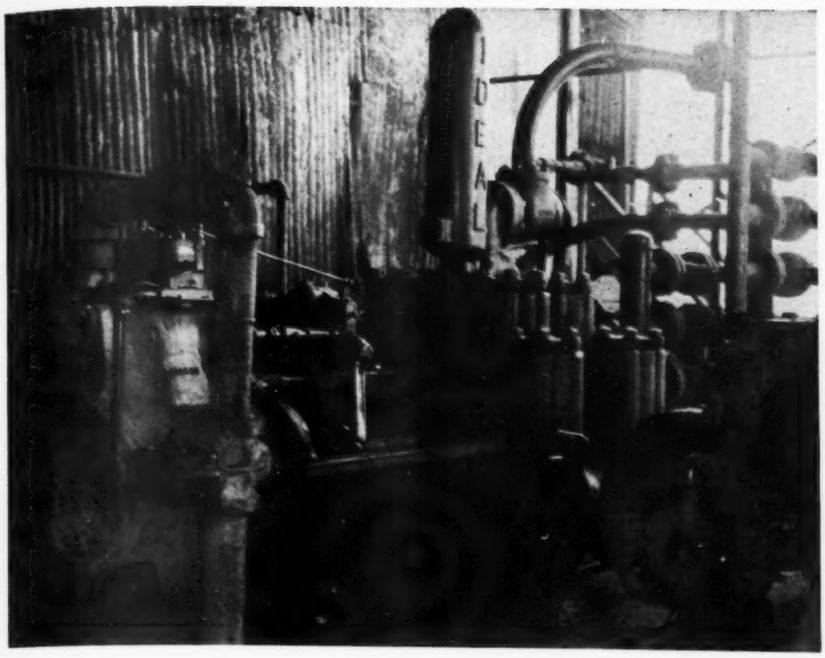
The deviation of the hole from ver-

Below—The deepest well in the world—Continental Oil Co. K. C. L. No. A-2, in the San Joaquin Valley, California





Putting in the slips while running the 3½-in. drill pipe to a depth below 13,100 feet



One of the 14 by 7½ by 18 mud pumps housed just outside the rig. Two pumps are in this house and a third is outside

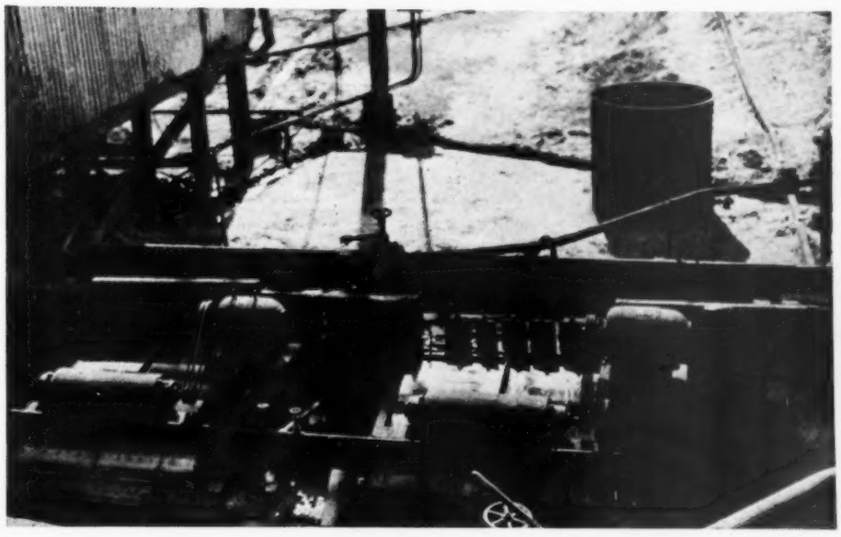
Wire-line coring was used to a depth of 11,570 feet. After this depth was reached cores were taken with conventional rotary core barrels.

The equipment used in drilling includes a 128-ft. derrick, a 34-26 drawworks, and a 12-in. by 12-in. engine. The derrick, however, is actually 136 ft. in height, as an 8-ft. vertical section was added at the top of the super-structure, and the crown block placed on that. The boiler plant consists of four 250-lb., 100-hp. boilers and a separately-fired superheater. The wire line used was 1⅛ in. in diameter. After a depth of 12,786 ft. was reached a 5-sheave block and ten lines were employed. Drilling is being done through a rotating blow-out preventer and additional control is provided by two cellar control gates.

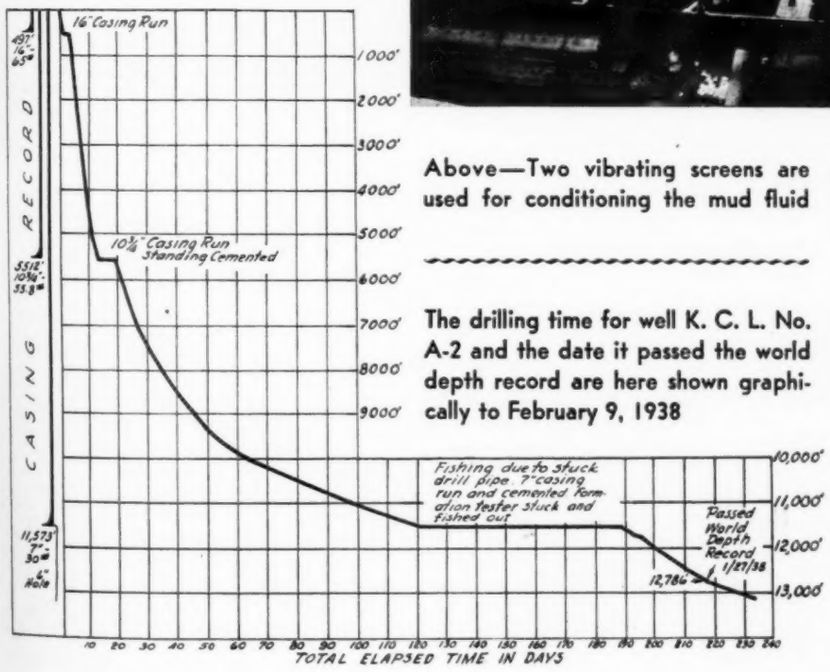
No definite comparison of the formations penetrated in this well with those drilled in the Union well 14 miles away will be possible until the well is completed. Present data indicate that the formations are not only deeper but thicker than they are in the Union well.

tical was determined by taking single-shot survey readings at intervals during drilling. An oriented survey was made at a depth of 11,700 ft. and the hole was found to be deflected only 21 ft. from the surface location.

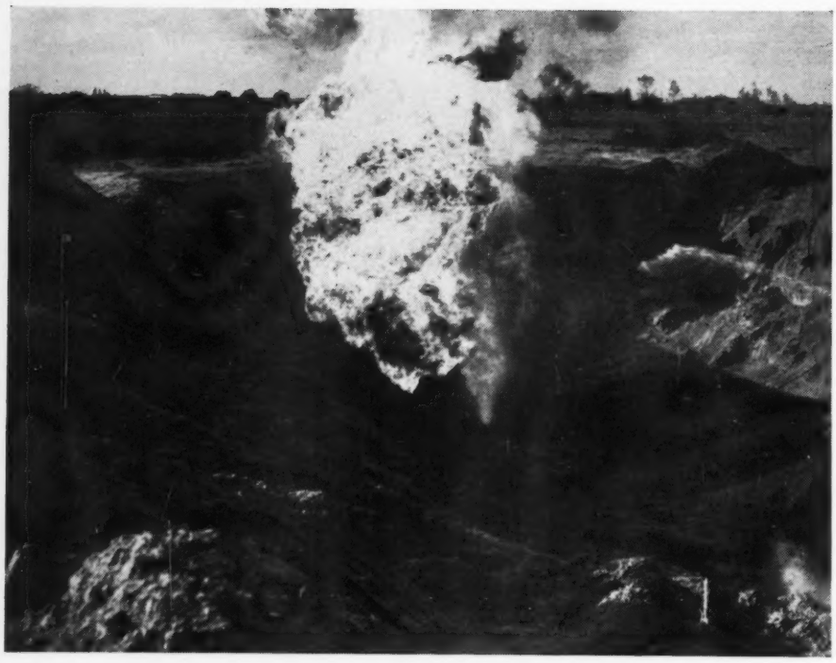
A record depth for electrical logging was established when a run was made to 12,789 feet. The instrument and cable were adapted to make measurements at this depth and no difficulty was experienced in recording the readings.



Above—Two vibrating screens are used for conditioning the mud fluid



The drilling time for well K. C. L. No. A-2 and the date it passed the world depth record are here shown graphically to February 9, 1938



The flaming twin gassers in the La Blanca field after the firefighters had dredged hundreds of cu. yd. of earth and debris from the crater. Blazing against the farther wall is the Davenport No. 1 Swallow, the abandoned hole. In the center foreground can be seen the exposed tip of the surface casing of the Davenport A-1 Swallow, the wrecked producer

By
BRAD SMITH

Efforts to extinguish and bring under control the cratered well in La Blanca field, Texas, thus far have been unsuccessful

Burning Gas Well Resists Control

ONE of the largest gas reservoirs in South Texas is the La Blanca field in central Hidalgo County, approximately eight miles east of Edinburg, the county seat.

La Blanca field was discovered in October, 1936. The discovery well, Pantano-Speed No. 1 Harding, a rank wildcat, blew out, ran wild, cratered and burned for five weeks. The total depth of the well was 7840 feet. The first producer, the Pantano Petroleum No. 1 Engelman, a mile east of the Pantano-Speed crater, was completed in January, 1937, as a gas and distillate well. It was completed through casing perforations in sand logged at 6666 to 6683 feet. The second producer in the field, Pantano Petroleum No. 1 McDougall, was completed in February, 1937, in a second sand logged at 7867-75 ft., proving two productive formations. Since that time at least four other producing sands, one as deep as 8500 ft., have been logged in other wells in the field. There are now seven producing wells in the field, which has a northwest-southeast length of two and one-half miles and an east-west width of one and one-half miles. No dry holes have been drilled. Pressures in the producing wells are 2800 lb. to 3400 lb. at the casinghead. The wells have been producing 85 to 125 bbl. per day of high-gravity distillate through ⅜-in. tubing chokes, and gas-oil ratios have been 40,000 to 82,000 cu. ft. per bbl. on Texas Railroad Commission potential tests.

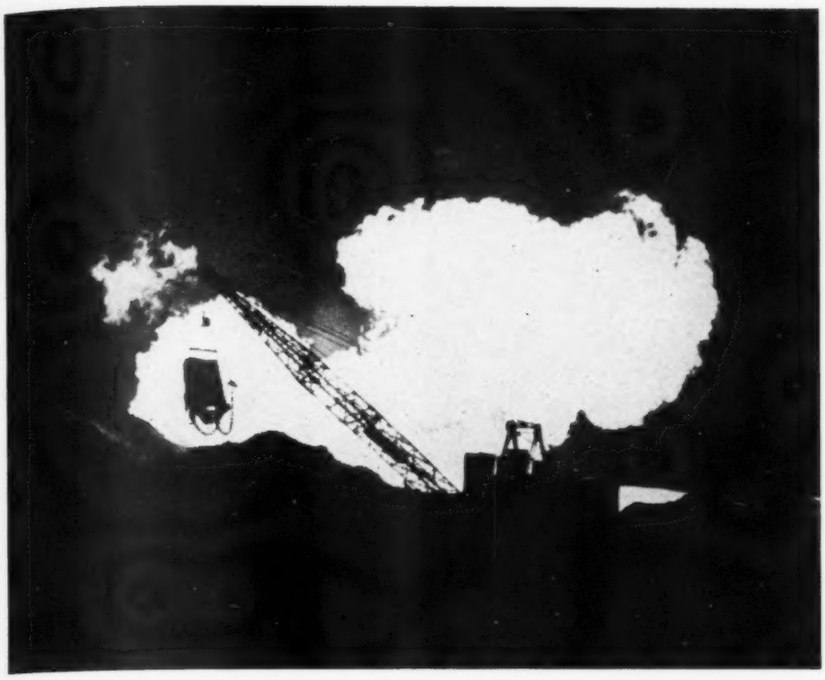
After nearly a year of operation the field was ordered closed in by the Commission on December 22, 1937, because of the waste of gas. All wells in the field were shut in on that date, except the Gulf States Oil Company's No. 1 Delta Orchards, about two miles northwest of the discovery well and a mile west of existing production. Operators there were allowed ten days to clean their new well, which was then being completed.

Closed-in pressures depend largely upon the number of casing perforations. In all wells in the field, casing was set through the producing sands, cemented with 300 to 600 sacks of cement, and then gun-perforated in the desired producing sand.

The fifth well completed at La Blanca was F. (Dee) Davenport's No. 1 C. H. Swallow. The first hole had been drilled to a depth of 7565 ft. before the drill stem twisted off. After the drill stem had been cut at 4398 ft., a whipstock was set and the hole sidetracked to 4621 ft., at which depth the drill stem went back into the old hole. The first hole was abandoned and the derrick skidded 50 ft. to a new location. The second hole was cleaned and production turned into lease storage tanks on October 20, 1937, after being drilled to a total depth of 7939 feet. A 7-in. O.D. oil string was set and cemented on bottom with 300 sacks of cement. Conductor pipe of 16-in. diameter had been set at 150 ft. and a protection string of 10¾-in. O.D. casing had been cemented at 1339 feet. Two principal sands were cored at 7503-65 ft. and 7829-7918 ft. as the well was being drilled; both contained gas and distillate. On completion, casing was gun-perforated with 18 shots at 7908 ft. to 7915 feet. When completely cleaned, the well flowed at the rate of 125 bbl. of distillate per day through ⅜-in. tubing choke. The working pressure was 3000 lb. on the tubing and 3200 lb. on the casing.

On the afternoon of January 8, 1938, closed-in pressures on both casing and tubing of the Davenport No. 1 Swallow were approximately 3150 lb. and there were no signs of leaks around the Christmas tree or its connections, according to the Davenport employee in charge of the Swallow lease. He later reported to his superiors that at 9 o'clock that night he heard a dull rumble outside his house, which was not more than 100 ft. from the well. Within a few seconds he heard what sounded like a small explosion. Running outside he saw mud and earth being blown from the ground near the abandoned well about 50 ft. northwest of the producing well.

About 4 o'clock on the morning of January 9, the ever-widening crater had engulfed the producing well. Within a short time the gas blowing from the old hole caused the Christmas tree to begin swaying. Finally the Christmas tree broke loose from the



A night view showing how the flames spread to burn all the gas blown into the air. Silhouetted against the flames is the dragline

casing. When it crashed, the gas in the huge crater caught fire.

The first firefighters appeared on the scene Sunday morning, January 9. They decided to flood the crater with water, forcing the flames to burn on top of the small lake thus created and giving them an opportunity to snuff out the blaze with a charge of nitroglycerin. An insufficient water supply forced abandonment of this plan.

H. L. Patton, oil-well firefighter from Houston, was then called to the scene by Davenport. Patton immediately ordered the water flow into the crater stopped. Within a few hours, the crater was practically dry but was considerably deeper than when water was first pumped into the hole. The water had softened the crater walls and the steady blast of gas against the west wall was gradually eating it away. The crater was 100 ft. wide and 60 ft. deep at this time.

After studying the situation, it was decided to dredge the bottom of the crater until the surface casing or Christmas tree of the producer could be found. A small dragline with a bucket of one cu. yd. capacity was available and with it they began digging a trench into the north side of the crater. The trench was begun about 100 ft. from the crater's edge and slanted toward the floor of the crater; a runway was thus formed for the huge derrick truck used by Patton in killing wild wells.

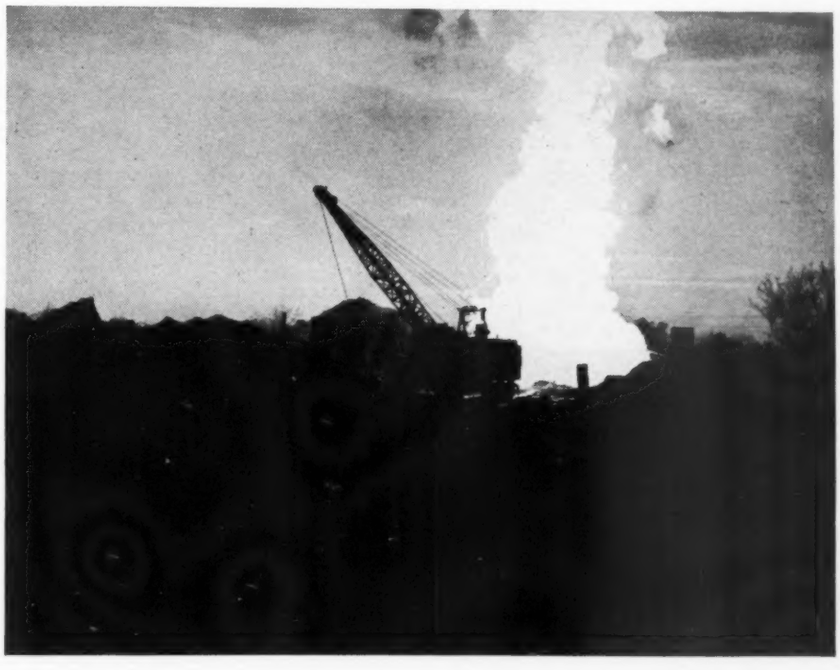
When the wind changed from the north to the southeast, blowing the flames toward the northwest, a larger dragline with a 65-ft. boom and a bucket having a capacity of one and three-quarters cu. yd. was brought from San Antonio. A 10-ft. extension was added to the boom. To protect the operator from the intense heat of the flaming well, sheets of corrugated iron were fastened around the cab. As a further protection of the boom, cable, pulleys, and bucket from the heat, a perforated water line was run through the boom to its tip.

After two weeks of day and night work, during which operators could work only in two-hour shifts because of the intense heat, another and deeper inclined trench was dug at the southeast corner of the crater. Beginning approximately 150 ft. east of the crater, the incline dipped to the crater floor, operators smoothing out a runway about 20 ft. wide.

When the trench was completed, the dredge was moved to the bottom of the incline, less than 30 ft. from the crater itself. As a means of further protection, a Caterpillar RD "60" tractor was tied to the dragline with a heavy steel cable to assist it in "walking" into and out of the crater as operators changed shifts or adjusted machinery.

From their vantage point near the edge of the crater, the operators dropped their big bucket repeatedly against the Christmas tree and surface casing of the producer. They completed their work in the crater on Friday, January 28, three weeks after the wells first blew out.

Meanwhile a "dead-man," made of 10 by 10 derrick timbers, had been sunk approximately 200 ft. east of the crater and a little north of the inclined trench. To this was fastened the heavy



Operators of the dragline were able to work only two hours at a time because of the intense heat, even though the machine was protected by sheets of corrugated iron and by sprays of water playing on it constantly

The crew tied a doubled steel cable around the casing of the wrecked producer and dragged it back to its vertical position, as shown here

crown block of the rig used in drilling the well. Nearer the crater was placed the rig's traveling block and cables were strung through the blocks exactly as when drilling a well. Patton then took the loose end of the cable, donned an asbestos suit, as did three of his men, and they walked into the fiery crater. Within a few minutes they looped the cable around the end of the surface casing as it lay on the crater floor. Meanwhile, the wild well raged and blasted at arm's length from them.

Successful in looping the cable around the casing, Patton and his men returned to the rigging atop the ground. They chained the other end of the cable to the drawbar of the tractor and began picking up slack in the line. As the tractor exerted its full strength, the line tightened and snapped near the traveling block. Four times Friday afternoon and Saturday morning the cable broke when strain was put on it. A new cable, of 1⅛ in. diameter, was ordered, the cable was doubled and the double lines strung through the crown block and the traveling block.

Again, the cable loop was fastened around the small section of surface casing in the fiery crater and again the other end was tied to the tractor's drawbar. This time the effort was successful, and the tractor jerked the casing to a nearly vertical position in the bottom of the crater and about five ft. above the crater floor.

When the force of the blast caused by the strong flow of gas was diverted from the west wall of the crater, tons of earth and debris fell into the small crater formed by the abandoned hole and it was immediately choked off and apparently effectively killed. Gas was now coming only from the surface casing of the producer, blowing almost straight upward into the air.

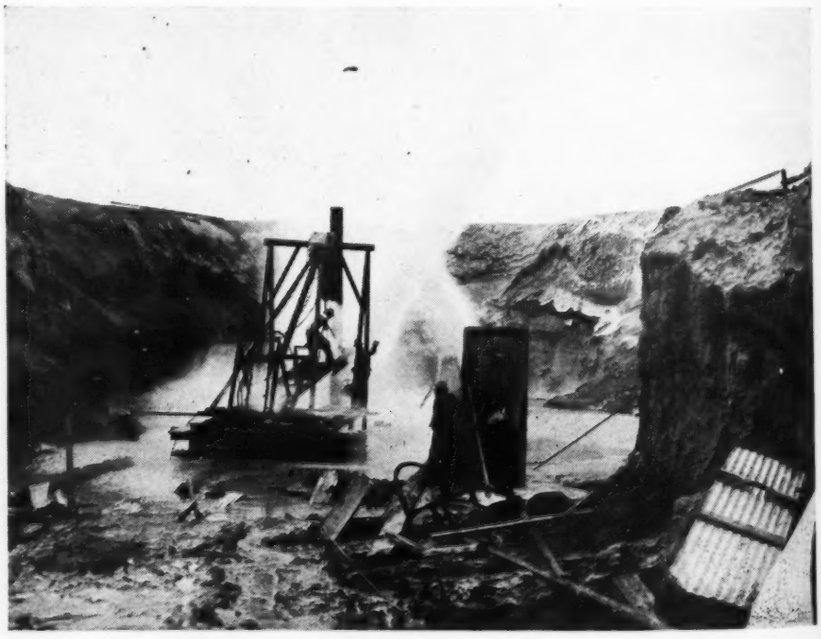
By Monday afternoon, January 31, the crater floor had been cleared and forms built for a concrete slab around the surface casing of the wild well. The slab, 16 ft. square and 2 ft. thick, was poured with Incor 24-hour, quick-setting cement to hasten the work.

While one crew was pouring the concrete slab, leaving a little space around the casing so that, should it become necessary or desirable to work against it later, it would be possible to do so, another began building a roadway of heavy derrick timbers down the incline to the edge of the slab. It is intended to back the huge 17-ton derrick truck down this runway into the crater.

Swung from the derrick is a huge manifold, fitted on the lower end with a swedge nipple. This cone-shaped nipple will be dropped into the casing of the wild well. Above the nipple is an 8-in. gate valve and above that a 13-in. gate valve. Surmounting the valves is a fitting upon which a tall smokestack can be placed.

When the nipple is lowered into the casinghead by means of the derrick, the valves are open. The gas, distillate, and flame pass through the nipple, the open valves, and the stack, burning at the top of the stack 30 ft. to 40 ft. above the nipple. The nipple is then forced into the casinghead by its own weight and by steel cables and clamps tied to collars bolted around the casing and around the upper part of the nipple. During the process of tying the nipple into the casinghead, workers are protected against leaks around the nipple by a shield eight ft. square made of ½-in. boiler plate. It is welded around the top of the nipple and set at an angle that will force the flame away from the men.

When a comparatively leak-proof connection has been made at the casinghead, all connections are then



The small derrick rigged up in an effort to set the smokestack over the blazing well. Two streams of water directed by workers from behind the corrugated iron shield kept the equipment cool and protected the workmen

The derrick handling the smokestack. Gas pressure blew the smokestack aside in the first attempts to set it over the casinghead

welded. Mud and water will then be pumped under pressure through connections on the nipple and the manifold into the casing and the valves will be closed gradually.

On February 1, since the foregoing was written, the original plan for killing the blazing Davenport No. 1 Swallow was abandoned temporarily.

After killing the fire in the abandoned hole, 50 ft. from the wrecked producer, it was intended to back the 17-ton derrick truck down an inclined trench to the floor of the crater and to drop a steel swedge nipple into the casinghead of the blazing well.

Closer examination of the exposed casinghead, from which the Christmas tree had been broken, along with one joint of 10¾-in. O. D. surface casing, when it fell into the widening crater of the well, showed that the 7-in. O. D. oil string had dropped into the hole several feet. The 7-in. casing had been cemented on bottom but not between strings.

A milling tool was used to drill a 4-in. hole in the 10-in. casing about 30 in. below the top. The 7-in. casing was not located. The milling tool stuck after the hole in the casing had been drilled. In attempting to remove it, a collar welded around the 4-in. hole was partly pulled off. Another hole will be drilled farther down the 10-in. casing in another effort to locate the 7-in. string. It may become necessary to cement between strings if it should develop that there is a leak in the 7-in. casing somewhere inside the 10-in., which was cemented at 1339 feet. If the 7-in. casing is leaking between strings, capping the 10-in. atop the ground would serve only to force the escaping gas, under high pressure, to make its way downward between strings and thence to the top of the ground outside the 10-in. casing.

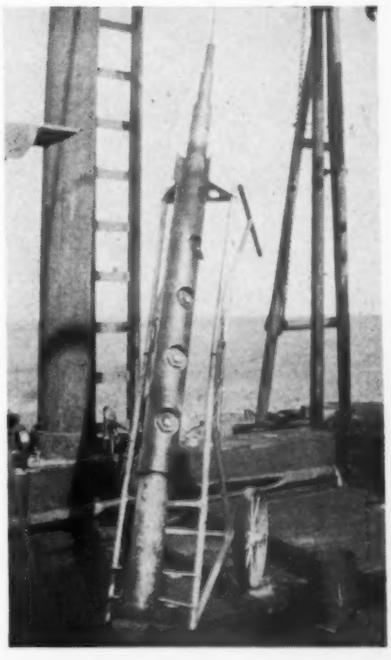
A small derrick was constructed of heavy pipe from which was swung a small hoist. The entire device was mounted on 8 by 8 timbers made into a skid. A 20-ft. smokestack was swung from the hoist and the derrick skidded into the crater. For two days, attempts were made to set the smokestack over the casinghead to cause the flames to burn higher above the crater floor, but they were unsuccessful. Further attempts to set the smokestack over the casinghead, thereby enabling workmen better to stand the heat, will be made.

Reconditioning Stripper Wells

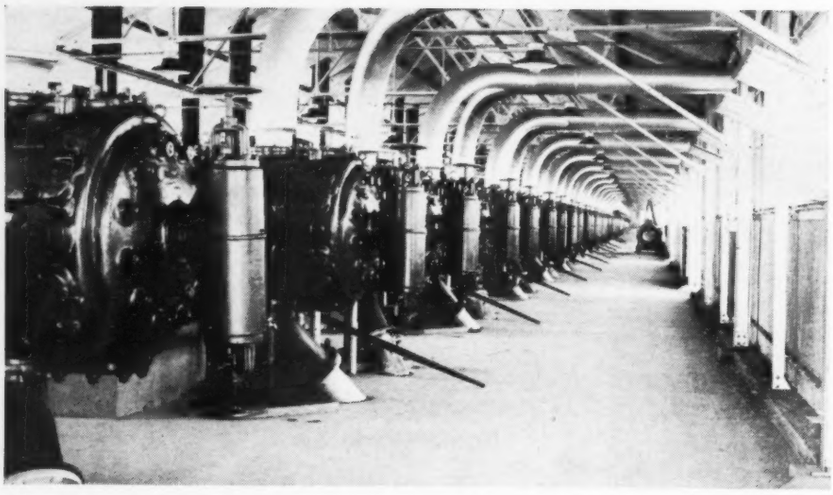
TO the operator of stripper wells the problem of reconditioning is one of recurring importance. The method employed varies with the condition of the individual well. It may be necessary to clean out and acidize, to cement casing, to cement off bottom-hole water, etc. When oil is known to exist at a shallower depth than the existing producing horizon, the gun-perforator frequently is used in connection with plugging back.

The gun-perforator, as its name indicates, is used to shoot bullets through the casing into the formation where oil is known or thought to be present in commercial quantities. It also has wide application to various types of remedial jobs, such as cementing casing, and in special methods of completing wells. This equipment was perfected by the Lane-Wells Company, and the construction of the gun may be seen in the accompanying illustration.

Recently two wells were reconditioned on the Cities Service Oil Company's Worrell lease in Kansas by pulling 5 3/16-in. casing, plugging back below the Kansas City lime, perforating 6⅝-in. casing below the Kansas City lime with a Hinderliter 4-way casing perforator, and cementing 6⅝-in. casing through perforations, after which several perforations were made with a Lane-Wells gun-perforator and the wells acidized. In this manner both wells were reconditioned successfully.



The gun-perforator, used to shoot holes in casing



Interior of compressor room, showing type of connections on low-pressure intake, designed to reduce line friction

By
J. C. ALBRIGHT

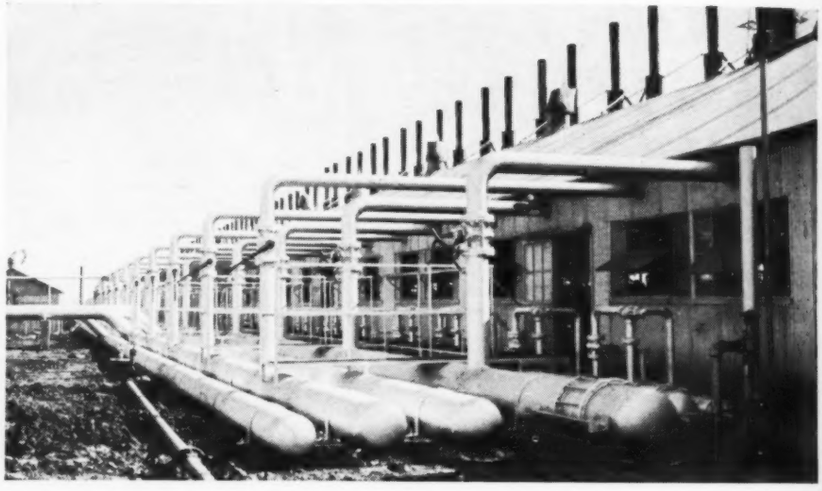
Modern 6750-Hp. Compressor Station Aids Gas Conservation

Gas produced with oil and not required for pressure maintenance and field operations in Edmond field, Oklahoma, is subjected to 3-stage compression for transportation by pipe line to available market.

NUMEROUS improvements in compressor station design and operation have been made within the last few years. Until quite recently it was general practice to bury intake and discharge headers. Laying these large headers in trenches entailed considerable expense and labor, and often within a few years the activity of corrosion necessitated extensive repairs, which were difficult to make.

The Edmond field, situated a short distance northwest of Oklahoma City, produces large volumes of gas with the oil. In line with conservation practices, the Phillips Petroleum Company and the Continental Oil Company, who process the gas in that field, are saving all gas not required for field operation and maintenance by compressing it and transporting it elsewhere as fuel for domestic and industrial consumption.

A large compressor station has been erected on one of the gently rolling hills almost in the center of the pool. It is operated by the Phillips Petroleum Company. The gas is compressed in three stages by 27 twin-cylinder, 250-hp. horizontal gas-engine-driven compressors having inverted exhausts. The units compressing the gas from the separators are equipped with 20-in. by 20-in. compressor cylinders that operate at field pressure; the high-pressure units have 7-in. by 20-in. and 11½-in. by 20-in. cylinders. Gas is delivered to the pipe line at a pressure of 450 pounds.



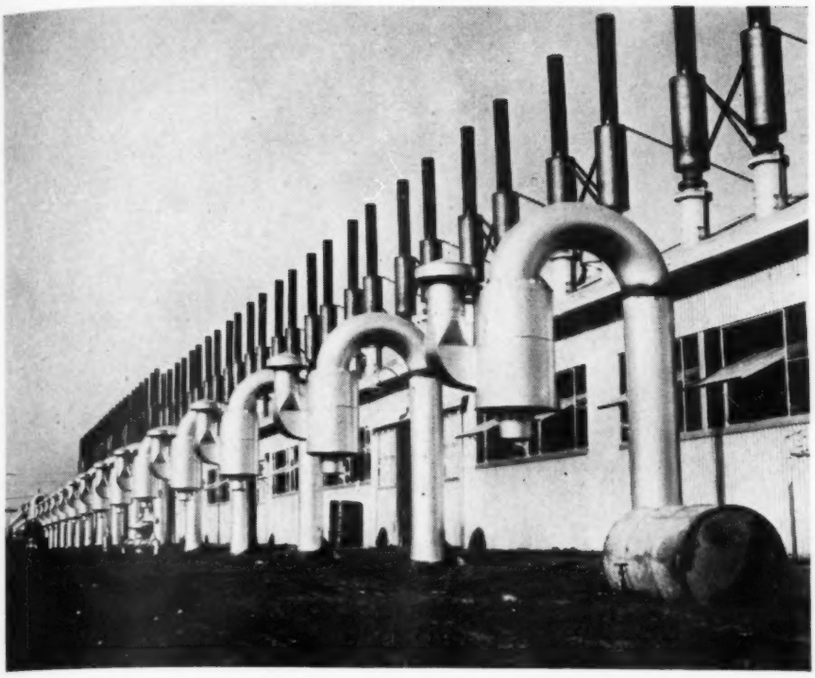
Station header arrangement

The building housing these engines is 420 ft. long, 26 ft. 6 in. wide, and 10 ft. high. The walls are corrugated iron and the floor is concrete. Where the floor is flush with the surface of the yard, the sills are raised to prevent rain water entering the room.

Adequate ventilation is provided by rows of windows and numerous doors. Roof ventilators have been installed at regular intervals on the comb of the building, permitting hot air to escape, and, as they tend to form a partial vacuum, allowing any gas that may pass packing glands to escape without forming a fire hazard. The building and all accessories are steel. No combustible material was used in the construction of the plant, and all possible precautions have been taken to prevent the escape of gas from flanged connections and piston-rod packing glands.

The soil in the Edmond pool is the typical red-bed clays deposited extensively in central Oklahoma. It forms an adequate foundation for heavy equipment. Excavations were made for the concrete foundations. Mats were laid from one engine foundation to another beneath the finished floor to provide adequate bracing and to prevent excess vibration.

After the engines were placed on the



foundations, piping to the compressor cylinders was installed. Discharge lines are laid beneath the floor. Before the concrete floor was poured around the stools and pipes insulation was placed between the metal and the concrete to permit expansion and contraction. Intake lines were connected to the intake flanges of the cylinders through the sidewalls of the building. The single-stage compressors require only a common line, branching to serve the two cylinders. As these lines are provided with fabricated pipe bends, pressure loss caused by friction is reduced to a minimum. All other connections are welded.

The power end of these compressors, conforming with modern engine design, has inverted cylinders, the exhaust piping extending through the roof of the building. Jackets surrounding the exhaust piping above the water-cooled section are removable to permit use of waste heat for heating the building. In warmer months these jackets are placed around the exhaust so that a draft will carry heated air from the building through the roof. Slotted-pipe mufflers have been placed on the exhaust stacks above the roof to reduce the noise. The air intake piping to the power cylinders is below the concrete floor, and is connected to oil-filled filters that prevent dust and other abrasives entering the power cylinders.

The power units and the compressor cylinders are lubricated by a full force-feed system. A mechanical lubricator supplies oil to pistons and rings, whereas journals, cross-heads, and crank pins are lubricated by a separate system. The latter is integral with the unit and consists of a force-feed, positive-driven pump, and oil filters that effectually remove particles of metal and dirt that may become mixed with the crankcase lubricating oil. The filters are the cannister type, rather than the bags previously used on this type of gas engine, and are accessibly placed on racks between the power cylinders.

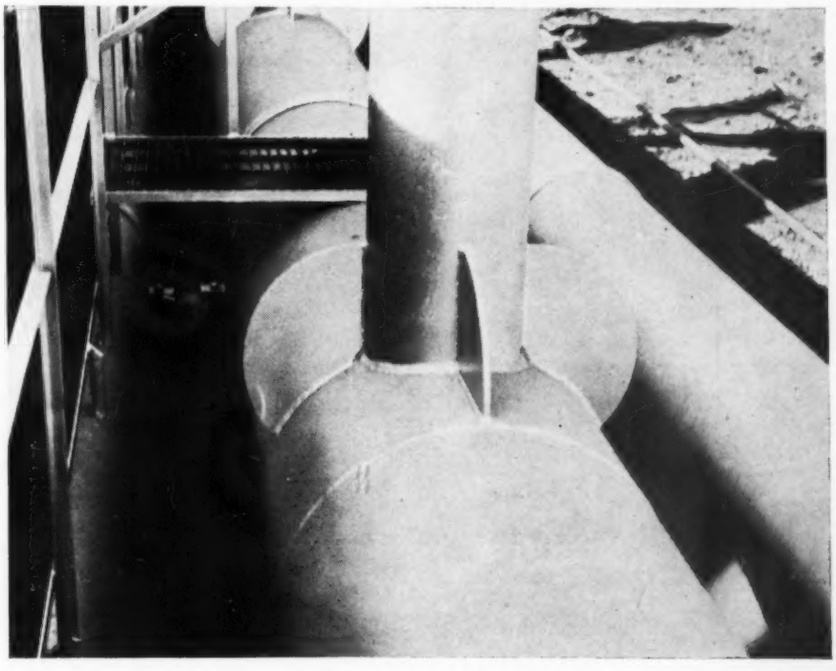
The gas is taken from the oil and gas separators in the field, transported

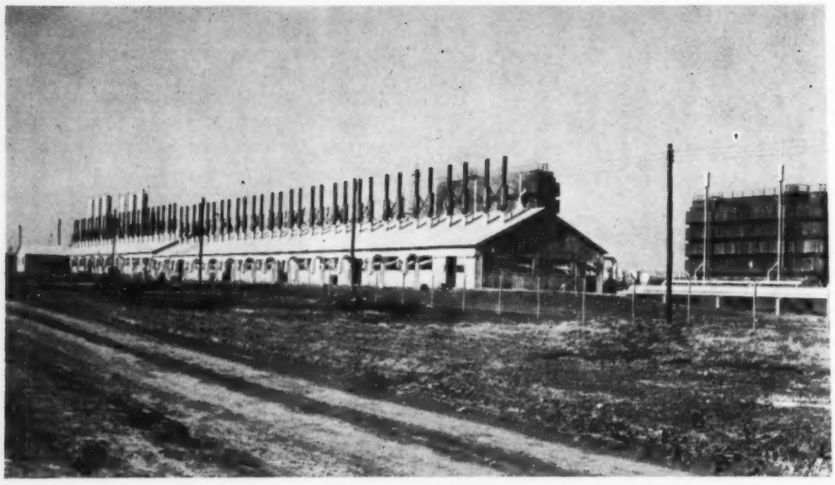
A suction line welded to a large-diameter header and braced to prevent vibration

Air cleaners

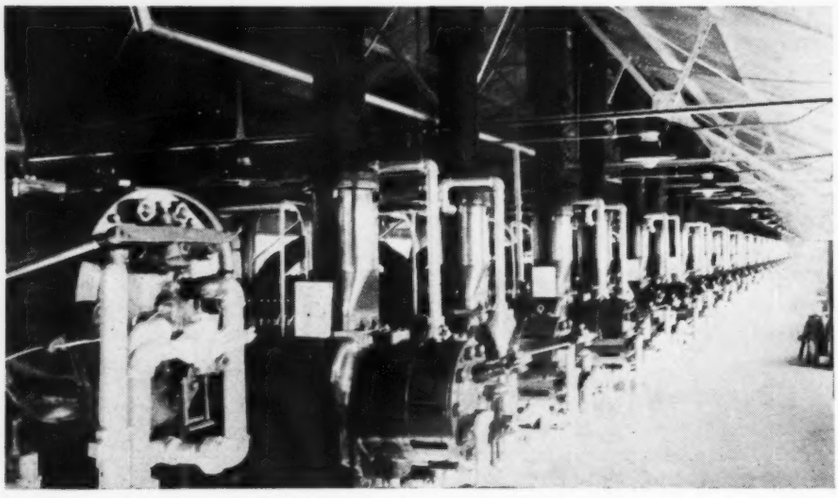
to the plant and passed through scrubbers. Oil, water, and other foreign matter are removed in these scrubbers and drained to accumulator lines. A large welded header is connected to the scrubbers, extending the entire width of the plant yard. Gas from this header, under varying pressure depending upon the operation of the wells in the pool, is introduced directly into the low-stage compressor cylinders.

This header extends in an east-west direction. At the east end of the building, where the ground is lower, it was necessary to support a large part of the header on concrete piers to make it level, preventing sags that might accumulate liquids. The header is large-diameter pipe, the joints being welded instead of being connected by conventional collars and threads. Risers from the header to the intake piping of the compressor cylinders are welded and braced with special fins attached to the header and to the risers. Control gates are provided to adjust the load for a particular engine, or to shut off the line entirely when one is down. To hold the header stationary on the piers it is secured by strap iron and bolts, the latter imbedded in the concrete pier. There are no cradle depressions in the concrete piers, therefore there is less surface contact between the header and pier, and pipe corrosion is retarded to some extent. The control gates on the low-pressure intake lines are the conventional rising-stem type, all stems pointing the same direction. These are situated above slip-proof step plates





General view of the Phillips-Continental compressor station in Edmond field



Exhaust piping on power end of compressors

upon which the operators stand when making adjustments.

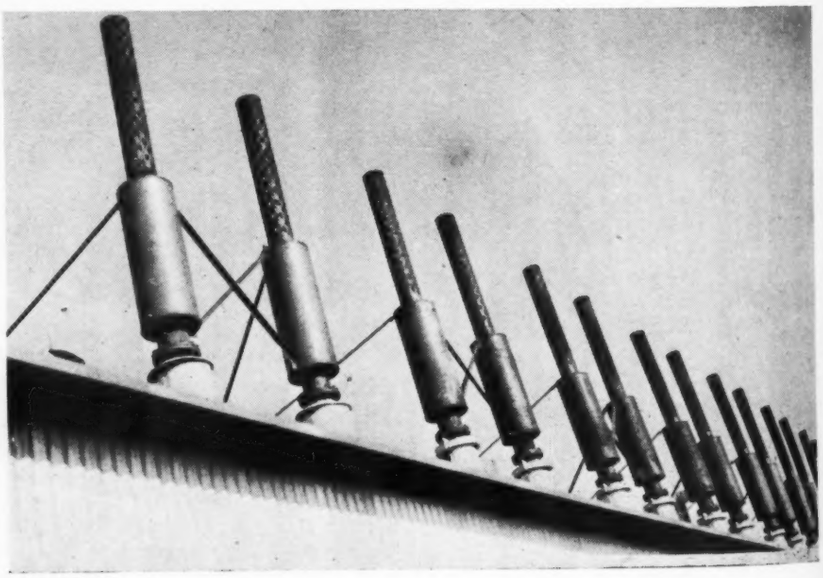
The discharged gas from the low-pressure cylinders, which operate at a pressure of approximately 45 lb. gauge, is transported through short lengths of buried piping. Valves controlling the flow of gas through this piping are installed below the surface of the ground just outside the engine room wall, where any gas leaking through stem packing will be dissipated to atmosphere instead of creating a fire hazard, as it would if released within the engine room. The discharge header from the low-pressure cylinders is laid parallel with the building and as near the engine room as possible, and leads to the processing equipment in which the gasoline is extracted.

Dry gas, at a pressure of approximately 35 lb. gauge, is admitted to the second-stage compressors, which have 11½-in. by 20-in. cylinders. Here the pressure is raised to approximately 140 pounds. The gas passes through cooling coils to the third stage of compression. All headers are laid in a manner similar to that of the low-pressure system, that is, strapped in place upon concrete piers. Piping from headers to gas coolers is carried aboveground to protect against corrosion. As no piping except short discharge sections is below ground, a high salvage value may be expected when and if it becomes necessary to dismantle the plant.

Gas from the second stage of compression returns to the high-pressure compressors after passing through the interstage coolers. The high-pressure units discharge the gas into a major gas transmission system that transports the fuel to consuming centers.

Relief valves are installed on all compressor cylinder discharge headers. The valve outlets are attached to a common header that carries the gas to a vent line beyond the plant yard. A steel walkway extends from each engine room door upward across the headers so that operators will not slip during wet or snowy weather. Also, a walk has been laid the full length of the engine room, above the headers and between them and the relief valve discharge header. All walkways are provided with guard rails.

Taken as a whole, this compressor station is designed so that it is operated economically, handled by employees with the least amount of supervision, and each engine is spaced from its neighbor so that repairs and adjustments may be made easily and with the least amount of interference from outside obstructions.



Extensions of engine exhausts, perforated to reduce noise

General view of United Gas Pipe Line Company's new compressor station at Shamrock, Texas

New Compressor Station in "Dust Bowl" Area Equipped for Air-Conditioning

Machinery and health of operating personnel protected by arrangement that provides for sealed buildings, the washing of all entering air, and the maintaining of air pressure inside buildings greater than that on the outside

By FRANK H. LOVE

BECAUSE of the prevailing weather conditions in the Texas Panhandle, engineers of the United Gas Pipe Line Company gave special attention to the design of the compressor station recently erected at Shamrock in that area. The station is situated in the Texas "dust bowl" and the harmful effect of the dust and sand upon moving parts of equipment, as well as upon the health of the operating personnel, had to be considered. It was decided that the most effective method of preventing damage to machinery from this source would be by rendering the equipment inaccessible to the dust by providing dust-proof buildings and maintaining an air pressure inside the buildings greater than the pressure on the outside. The buildings are sealed as tightly as possible and the entering air is washed. The air-conditioning idea is also extended to include the company cottages in which the operating staff and their families reside. The system is such that the equipment can be utilized for air-conditioning in the summer and for heating purposes in the winter.

In the air-conditioning system for the main station building and the auxiliary building, air is drawn in from the outside through louvers built in the wall of the auxiliary building. The air immediately enters the air washer, in which it is washed by alternately passing it through sprays and eliminators, there being two sets of each. Air flows from the final eliminator to two fans, one discharging through an aerofin steam-heated air coil into a duct that in turn discharges into the auxiliary building. The second fan discharges through similar heating coils into two 30-in. diameter underground ducts that transport the air to the main building. The use of this arrangement permits heating of the washed air if desired.

The water used in washing the air is circulated by two close-coupled motor-driven centrifugal pumps. Piping is so arranged that water may be heated by passing it through a condenser, wholly or in part, and it may be discharged into one or both spray headers. The water discharged from the set of sprays and eliminators closest to the air entrance is directed to flow by means of a baffle into the mud settling chamber of the air-washer pan, thereby reducing the amount of silt circulated by the pumps.

The fan that boosts washed air to the main building is driven by a variable-speed motor the speed of which can be reduced as much as one-half when desired. A vane-controlled fan blowing air into the auxiliary building is driven by a constant-speed motor. Air discharged into the main building can be supplemented by that drawn from the jackets surrounding the vertical exhaust pipes of the main engines. Air from this source, used to cool the engine jackets, is drawn into a central duct by a fan operated at constant speed and may be discharged either to the atmosphere or into the ducts carrying air to the main building.

The buildings were constructed of corrugated sheet iron, and to make them as tight as possible the sheets were lapped two and one-half corrugations instead of the customary one and one-half. In addition a felt tape was placed between the lappings, and the doors and windows were weather-stripped, the former with flexible metal and felt strips, the latter with sponge rubber. Cracks, other than those weather-stripped, were treated with a caulking compound.

In the company's camp are four five-room houses and four four-room houses, and these, too, are air-conditioned. At the rear of each house has been installed a forced-air furnace equipped with dry-cloth filters. Ducts are so arranged that the air drawn into

Compression end of the compressor units. Above can be seen the jackets that surround the main engine exhausts

the house from the outside, as well as the return air from the house, passes through the filter into the heating unit, then is discharged to the various rooms through grilles built in the walls near the ceiling. The units are automatically controlled by a thermostat placed in the living room of each house.

The 16-in. line on which this new station was constructed takes gas from the fields north of Shamrock and extends to Wichita Falls. Four 300-hp. vertical gas engines driving horizontal 6¾-in. by 12-in. compressors have been installed. Gas is brought from the field through a 16-in. line and is measured by orifice meters ahead of the scrubbers. The scrubbers, each having a daily capacity of 30,000,000 cu. ft., have 10-in. connections. A 12-in. line bypasses these scrubbers. Upon leaving the scrubbers the gas passes through a 20-in. line and enters a 20-in. header immediately outside the compressor building. From the 20-in. header 8-in. suction lines lead to 8-in. headers situated above the engines. Suction is taken at the top of the cylinders, the gas compressed and then discharged at the base of the cylinders through 4-in. lines into common 8-in. headers for each engine, then passed through 8-in. valves into a 16-in. line that carries the gas to a bank of open-type coolers situated in the base of the cooling tower. In these the gas is cooled approximately 50 degrees. The tower is 24 ft. 7 in. by 48 ft. 2 in. by 38 ft., and has a capacity for cooling 1000 gal. of water per minute. Water is circulated over the cooling tower by motor-driven centrifugal pumps. There are no aftercoolers, the gas, upon leaving the open-type coolers, going directly to the main transmission line through a 16-in. feeder line. Remote control valves have been installed both on the 16-in. inlet and the 16-in. outlet lines.

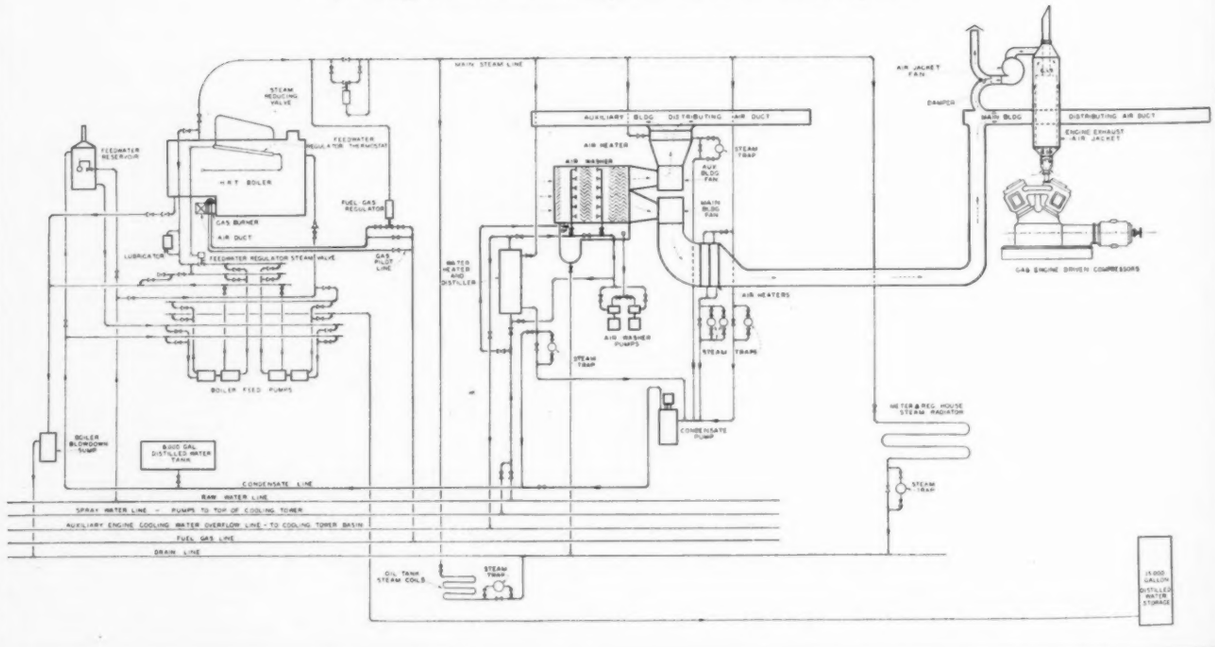
To cool the engines distilled water is circulated through the jackets by a centrifugal pump that is an integral part of the engine. This water is cooled

Two 30-in. ducts, before being covered, through which air flows from the auxiliary to the main station building

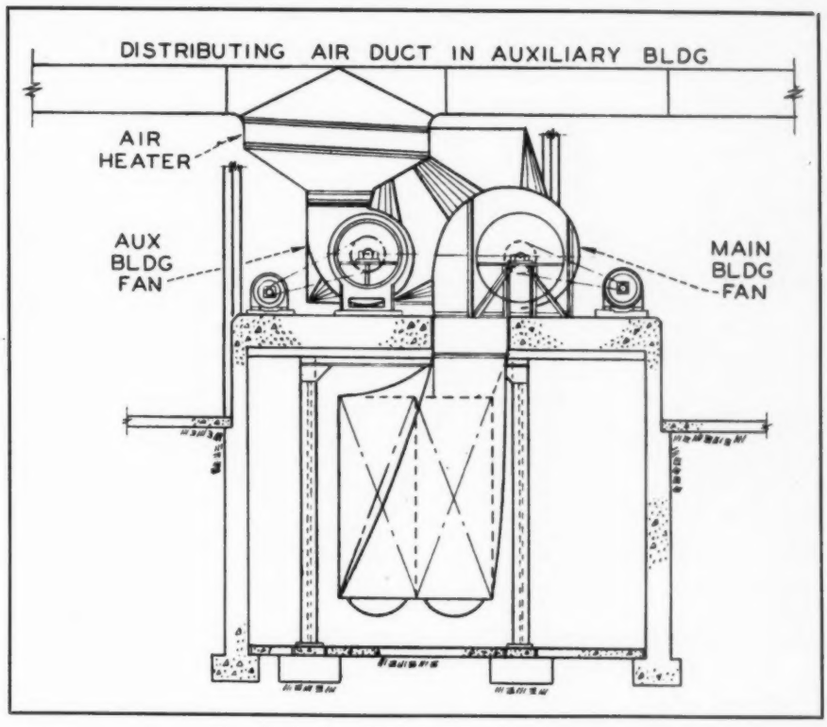
by pumping it through four open-type coolers having a total surface of 1950 sq. ft. and being capable of reducing by 25 deg. the temperature of water flowing at the rate of 600 gal. per minute. The steam from the still is condensed by a condenser that also is used as a water heater in the air-conditioning system. Storage capacity for distilled water is 15,000 gallons.

Fuel for all engines can be taken either from the high-pressure or the low-pressure side of the line, and is re-

Flow diagram of the heating and air-conditioning system



Cross-section showing arrangement of fans



duced to a pressure of 12 oz. ahead of the regulator of each engine, then to approximately 1 in. of water at the engine.

Engine lubricating oil is conditioned intermittently by a centrifuge. The equipment employed in reclaiming this oil consists of a conventional type centrifuge and a tank having three compartments, situated in the auxiliary building. Clean oil is pumped from the tank to the engines, the dirty oil returning by gravity flow. The first compartment is a settling basin and from it the dirty oil overflows into the second compartment. The oil goes from the latter to the centrifuge, and is then returned to the third compartment, whence it is pumped to the lubricating systems of the various engines.

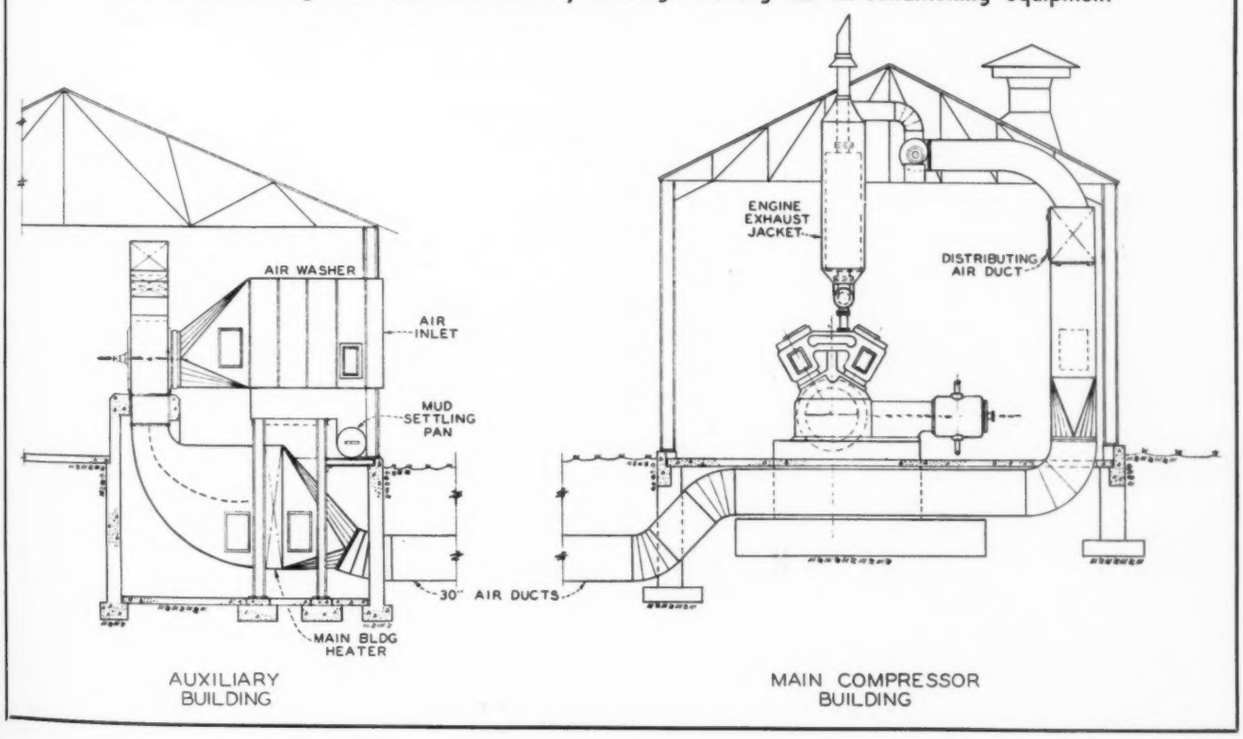
Steam required to operate the plant is provided by a 60-hp. boiler equipped with a feed-water regulator and a fuel-gas regulator. Two 3-in. by 2-in. by 3-in. steam-driven pumps are employed both as boiler feed-water pumps and to pump distilled water into the 15,000-gal. storage tank. Condensate from all steam lines is discharged through traps to a motor-driven centrifugal sump pump, which forces it either into a small distilled-water storage tank or into the boiler feed-water reservoir.

Starting air is supplied at a pressure of 250 lb. by two motor-driven air compressors. Air is transported to the main and auxiliary engines by overhead 2-in. lines.

The equipment for generating the electric power required in the operation of the station consists of two 110-hp., 327-r.p.m., 10-in. by 12-in., 4-cylinder, vertical gas engines direct-connected to 94-kva., 3-phase, 60-cycle, 440-volt generators. Cooling water for the auxiliary engines can be taken from the fresh water line, the cooling tower, or the distilled water system.

Although it was not assumed that the air-conditioning would totally eliminate the dust from the buildings, "dusters" that have occurred since the station was placed in operation indicate that it is of great benefit to both the personnel and equipment of the plant.

Cross-section through the main and auxiliary buildings showing the air-conditioning equipment



WPA Writers Review Story of West Virginia Oil Fields

DURING the last half-century West Virginia has made rapid progress in the production and development of petroleum, and the event which, probably more than anything else, made this progress possible, occurred just 48 years ago. In July, 1889, Dr. Israel C. White, West Virginia state geologist and world authority on oil geology, began drilling the well that was to demonstrate beyond question his ability to locate oil deposits by anticlinal waves.

The new vista thus opened to the oil industry by Dr. White has provided research workers employed on the Writers' Project of the Works Progress Administration with material for a story that will be featured in the West Virginia section of the American Guide.

Data compiled by the research writers tell how Dr. White discovered the famous Mannington oil and gas field and describes some of the obstacles he encountered in attempting to open the field. Although a scientific account of the original operations was written by Dr. White, it remained for a WPA research worker to reveal many interesting sidelights heretofore unpublished.

Operations began on the D. F. Hamilton farm, near Mannington in Marion County, West Virginia. Two small farms adjoining the Hamilton farm could not be leased on reasonable terms, but all other adjacent lands lying northeast into Monongalia County and south into Harrison County were leased, before drilling started, in the name of T. M. Jackson Company.

A separate company in each of the three counties, Monongalia, Marion, and Harrison, took over the leases, but Dr. White, T. M. Jackson, and others held an interest in all. In Marion County the company was called the Jackson Oil Company and was composed of five men—Col. C. L. Smith, Dr. White, Mr. Jackson, Major A. L. Prichard, and A. W. Prichard. The two most important members of course were Jackson, who was professor of civil engineering at West Virginia University, and Dr. White, who was professor of geology at the same institution as well as the official in charge of the United States Geological Survey in Pennsylvania. All these men are now dead except Major A. L. Prichard.

The oil fraternity had always cast a skeptical eye on Dr. White's method of locating oil and gas pools by the structural or anticlinal wave theory. Five years before the Hamilton No. 1 was located, guided by his theory, despite all skepticism, he had found the important field at Washington, Pennsylvania, as well as the celebrated Taylortown field in the same county, and other important fields in Westmoreland County. But now again his location of the Fairview and Mannington fields was questioned; practical oil men shook their heads and declared that the locations were several miles too far west.

Early in the spring of 1889, Jackson had made a complete survey map of all wells in the Mount Morris, Pennsylvania, field, 25 miles east of Mannington, and had taken the elevations of the coal beds southwest through Monongalia, Marion, and Harrison counties.

Dr. White faced the crucial test of his theory. The location on the D. F. Hamilton farm was made for oil, and the stake was driven by Major Prichard. There was no producing well within 20 miles. If the attempt should fail, it would be a severe blow to oil geology.

When the learned professors announced that Mannington and Fairview were over their pools, they were subjected to many jokes, and it was only by making liberal lease gifts that Dr. White could induce any contractor to risk money on the test. Finally, A. J. Montgomery, who had a knowledge of geology, agreed to drill a test hole on the following terms: if, when he had drilled through the "Big Injun" sand, no production was found either of oil or gas, he would receive no pay for his work; if, on the other hand, the well was productive of oil or gas in paying quantities, he would transfer one-fourth interest in the well for a three-fourths interest in 3000 acres of leases adjoining the Hamilton farm.

Work was begun on the test well on July 22, 1889. The well was drilled in November 7, at five o'clock in the afternoon, and completed November 11, at a depth of 1928 ft., within a few feet of the bottom of the "Big Injun" sand. The professors had struck oil in paying quantities; it flowed out the top of the casing!

To keep the strike a secret until the two adjoining farms could be leased, the well was plugged by hammering wooden plugs into the bottom of the hole.

Excitement was at fever pitch during the drilling-in of the well. The public road leading over the hill from Mannington was crowded with people from far and near. They lined-up behind the high fence about 200 ft. from the well, fighting for the best knotholes. Spies from various large oil companies, including "Billy the Weasel" from the Standard Oil Company, were present. Through his field glasses Billy saw through the cracks of the fence boards that oil had flowed out the top of the hole. Though he kept this information from the public, he twitted Major Prichard about what he saw in the enclosure. The people were speculative, curious, and alert, and it was not long before they too learned that oil had been discovered in the "Big Injun" sand nearly 2000 ft. below the surface. It has been claimed that this was the deepest well ever drilled up to that time.

The best deep-well sinking methods known were used in drilling the Hamilton well. The hole was cased with 10-in. pipe in the Pittsburgh coal, which was 11 ft. thick and 459 to 470 ft. below the surface. Eight and one-half in. casing was run inside the 10-in. from the surface and landed in the "Big Lime," at a total depth of 1770 feet. From there on to the bottom of the hole there was no casing. The well took only four months to drill.

Following the completion of the Hamilton well, a new company was formed under the name of the Flaggy Meadow Oil and Gas Company. A. J. Montgomery held three-fourths interest and the five men who composed the Jackson Oil Company held one-fourth interest in the new company. By thus letting control pass from their hands the original five lost an opportunity to make themselves wealthy; but Dr. White was a geologist, not a financier.

The next well was drilled by this new company, about two miles southwest of the Hamilton well, at the head of Salt Lick Run. Dr. White located it strictly for gas, in order more fully to demonstrate his anticlinal wave theory; otherwise the company would have drilled for oil, because gas was not then in great demand. This well, like the other, was a pioneer adventure.

After much trouble caused by sticking of the tools, the new well struck gas in huge quantity in the "Big Injun" sand, exactly as planned. This was the first well drilled for gas in the Mannington and Fairview district. The gas was piped and sold to residents of Mannington at very low flat rates. Prior to this all boilers for drilling had been fired by wood; from that time on they were fired by gas. The well is still producing gas.

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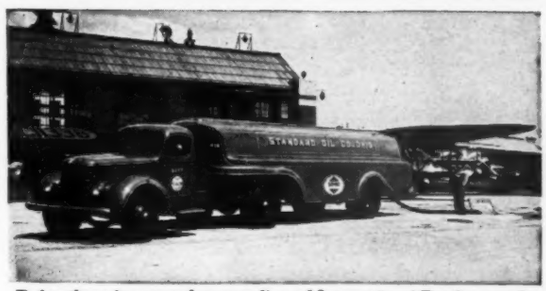

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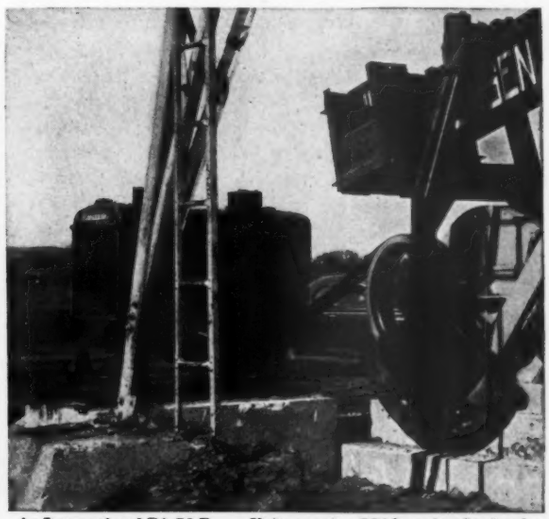

An International PA-50 Power Unit pumping 550 barrels a day for the National Refining Company on the Ryanhart lease near Russell, Kans.

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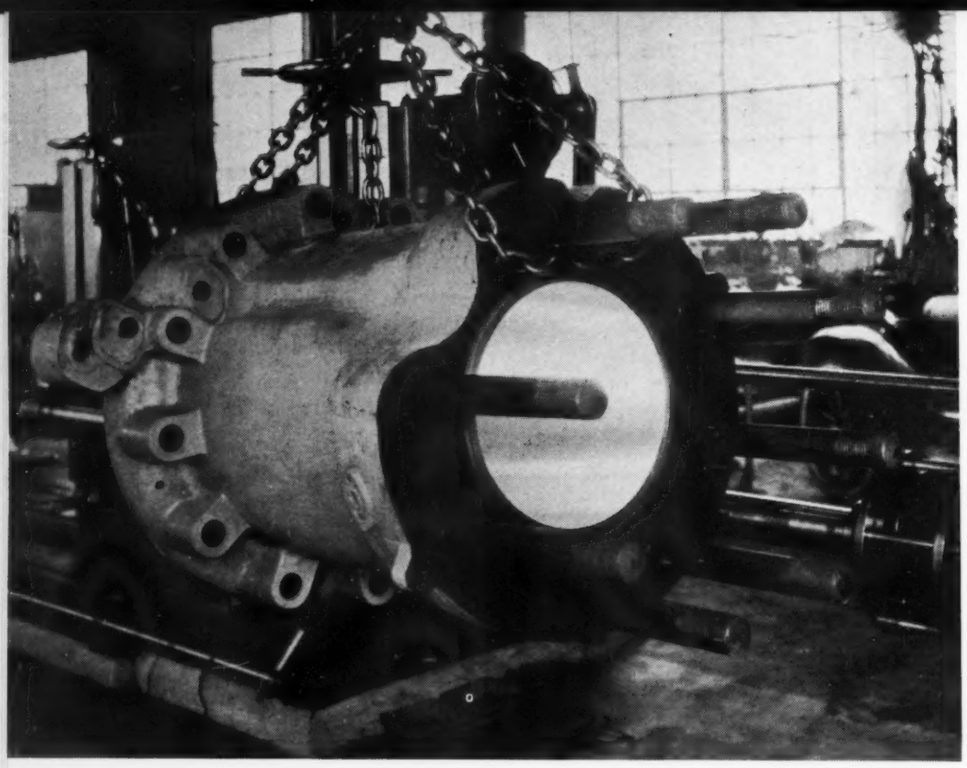

Inside surface of cylinder ground to a glass-smooth finish

By

ORVILLE ADAMS

Improper operating methods can nullify all the scientific improvements built into the engine

Cylinder Overhaul and Maintenance

MANY operating engineers think that wear on cylinder liners and rings results from a number of unidentified weaknesses inherent in the design and operating conditions of all internal combustion engines. Much research and considerable experimental work has been performed in connection with these problems. No doubt much of it is confusing to the practical man in the field, particularly the claims made by the various investigators for their methods of correcting the defects. Certain methods of finishing the cylinder bore are advanced as means of reducing liner wear, prolonging the life of the piston rings, and increasing the fuel efficiency of the engine over long periods of time. Certain designs of pistons have been found to increase the useful life of the liner and to increase efficiency considerably; also, there is much to be said in connection with lubrication, heat dissipation, and proper load for a given cylinder size.

When all factors are taken into consideration, and the problem considered as a whole, much confusion can be avoided, with the result that immediate problems may be analyzed with a greater degree of exactness and the remedy applied whenever instances of excessive wear, ring replacement, and too frequent overhaul are encountered.

Investigators in the field of lubrication have shown by numerous data and studies that practically no wear occurs in the presence of a complete oil film to prevent metal to metal contact, provided there are no abrasive particles in the oil film. So long as this ideal condition exists in an engine cylinder, the nature of the surface of the liner, the rings, and the degree of hardness are not highly important. In too many instances, however, this ideal condition either does not exist or is so intermittent that for practical purposes it is inadequate. On the other hand, many engines have been observed in which the fuel efficiency continued to increase after installation, for months in the high-speed engine, and for years in some slow-speed engines, during which period the efficiency was actually as much as 20 percent greater than guaranteed, and liner and ring wear was practically non-existent. There is little doubt that this increased efficiency in the early life of the engines and cylinders was caused by improvement of the surfaces of the cylinder and rings, which become smooth and glossy in operation, wearing-in of the bearings, and the reduction of various friction losses. The cylinder, pistons, and piston rings attained an ideal mechanical condition that made possible an almost perfect lubricating film.

Though many investigators admit they are unable to define wear, it very definitely is asserted that hardness as determined by penetration is not a satisfactory measure of a metal's capacity to resist wear. It is likewise claimed that tensile strength and other physical properties often emphasized do not indicate wearing qualities of the metal when subjected to the conditions that exist in an engine cylinder. Almost every wear test that has been reported was conducted with dry surfaces, as it is asserted that, because wear actually occurs in the cylinder during dry periods when the film of oil has been lost, dry tests indicate true conditions.

One investigator found that some irons would "work harden", that is, "glaze," after some time in operation, the cylinder liner and rings developing wear-resisting films, and that some metals would attain such qualities to a greater degree than other metals used in the experiments. It has been observed in tests, as well as in actual service, that the softer and coarser-grained cast irons show a greater tendency to develop wear-resistance than do the harder, fine-grained metals so much used for such structures; no extensive data to support this view have been reported, however. No doubt the softer cast irons, with a greater graphite content, have an inherent capacity to reduce wear. This is evidently closely akin to the observed fact that cast irons that present a "pitted" appearance after use, somewhat resembling a bearing metal surface, show the best wearing qualities, due in part, no doubt, to the removal of imbedded particles of soft graphitic iron. This is further supported by a fact observed by this investigator that the cast irons that wear most rapidly develop quickly a surface that takes an intimate or snug fit against the cylinder and has few

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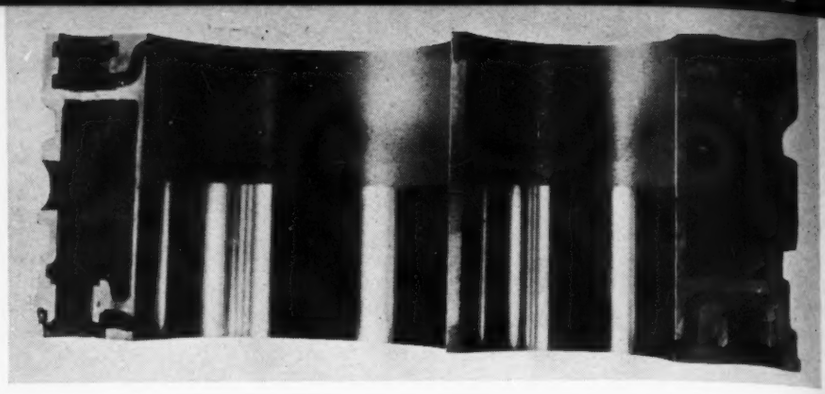


Showing by contrast the two kinds of finish of the bore

high spots making contact with the liner surface.

This brings the discussion to the relative importance of the cylinder or bore finishes. Opinion is divided concerning the importance of the cylinder finish in determining the initial and subsequent wear. This might be termed the "Bored vs the Ground" cylinder. Practically all small high-speed engine cylinders are ground with an internal grinding wheel that finishes the cylinder by transverse grinding, after which the cylinder generally is honed longitudinally to prevent the "file effect" of the transverse corrugations. The larger cylinders are generally bored and rough-finished by a honing process, but a wearing-in period is depended upon to establish the running fit.

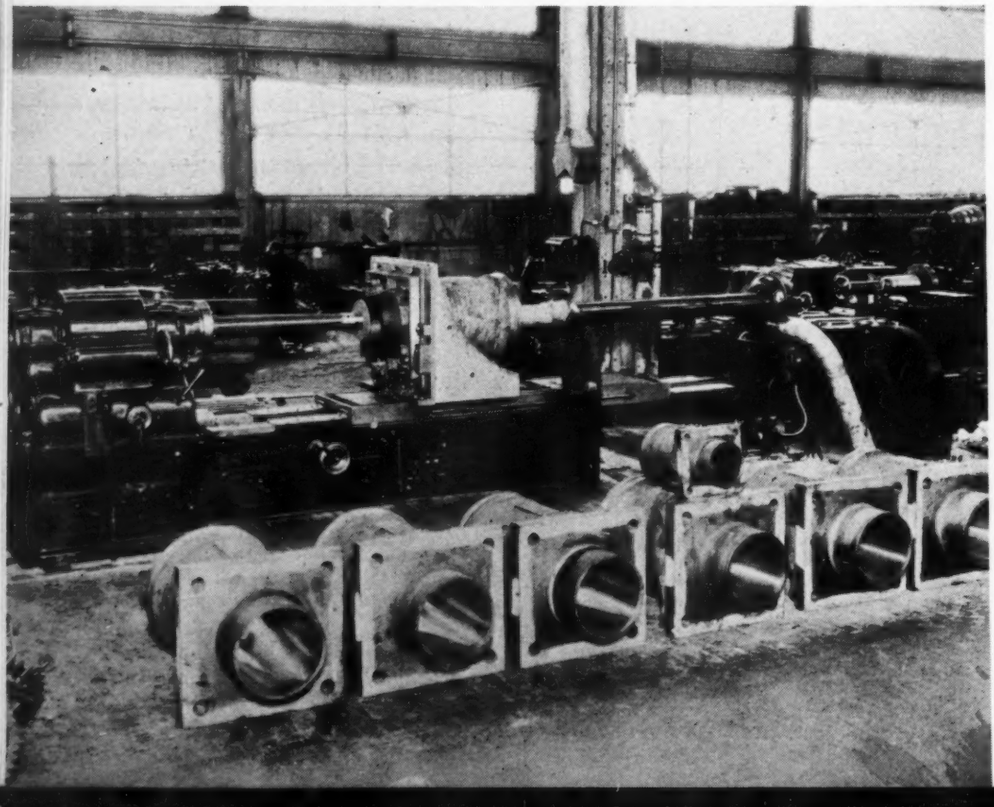
Tests have been reported in which ring wear was 50 percent greater during the wearing-in period in cylinders finished by transverse grinding than in those finished by co-directional travel. It is found that the rings, traveling over these minute corrugations, first must knock off the high spots, resulting in scuffing the surfaces of both cylinder and rings. During this period, iron dust from the wearing-in is deposited in the lubricating oil, thus increasing the abrasive effect. There is some objection to burnishing a cylinder surface to a mirror-like finish by grinding, and it is concluded that it is much better to finish a cylinder bore with a surface similar to that obtained by actual running.

In the field, after an overhaul, particularly if after the grinding or boring of the cylinders they are not finished in a manner similiar to a run-in fit, much wear occurs during the run-in periods, and it is desirable to prevent this short period of excessive wear. The wear at this time is many times as great as it is after the engine is run-in and the surfaces of the cylinder are satisfactorily glazed, the rings seated-in and the wear-resisting film on the metal produced to a degree that a continuous film of lubrication is possible. Lapping-in the rings and pistons when cylinders and rings are replaced might reduce the wear that occurs during the run period, and eliminate considerable wear; however, it appears quite likely that a certain amount of wear must take place before the conditions sought are realized. Obviously, then, the solution to these problems is only remotely related to the structure of the metal used or to the method of finishing the cylinder bore.

In well-designed engines of the type in use today, it is possible that these two factors have little or nothing to do with wear. Piston rings actually have been run continuously for several years without replacement and without showing excessive wear, without scuffing of either surface, and with little wear on the cylinder liners. Instances of this kind turn up frequently, particularly where engines have been efficiently and intelligently operated. It seems that these are not important factors in determining engine life or wear, and rank below many other factors, such as the range of operating conditions encountered in actual service, the amount of care exercised in maintaining a balanced engine, the extent of overheating and overloading, and the cleanliness of fuel and lubricating oil.

A few facts, however, should be kept in mind. Ground cylinders reduce the running-in time, and doubtless require that less metal be worn away before the desirable glass-like smoothness is attained and the ideal operating condition approached. More uniform cylinder fitting is made possible if the grinding is performed properly. Replacement liners may be run-in finished by honing, which is desirable. Certain types of piston rings, designed to reduce wear and maintain a more nearly uniform film of oil, certainly contribute to longer liner life.

Liners have been known to last for 12 or 15 years before being replaced, and the engines gave high fuel efficiency during most of this time, although operating almost continuously. On the other hand, the same type of engine will be found to have required liners within three to five years under conditions that on the surface appear to be no different insofar as the effects on the liner wear and ring replacement are concerned. The conditions encountered in actual service, such as the care exercised by the operating engineer, the maintenance practice, cooling, kind of fuel used, lubrication, and load factors, perhaps determine just how long the liners will last, and the amount of ring replacement really necessary. After all the aids and improvements developed by the engineers have been provided, it is up to the practical operating man to obtain the results; hence a great deal of study and care on his part is warranted.



How cylinders are ground at the shop

Purification System

3

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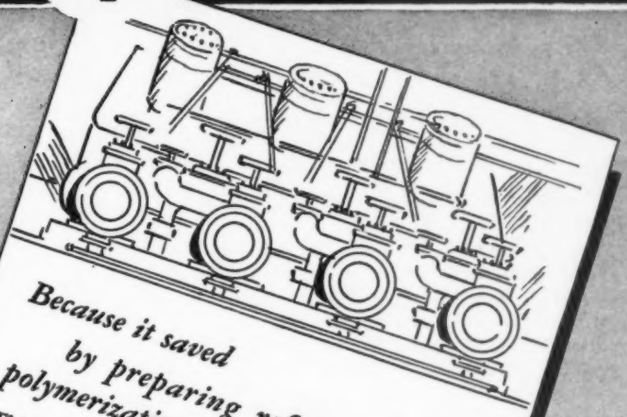
4



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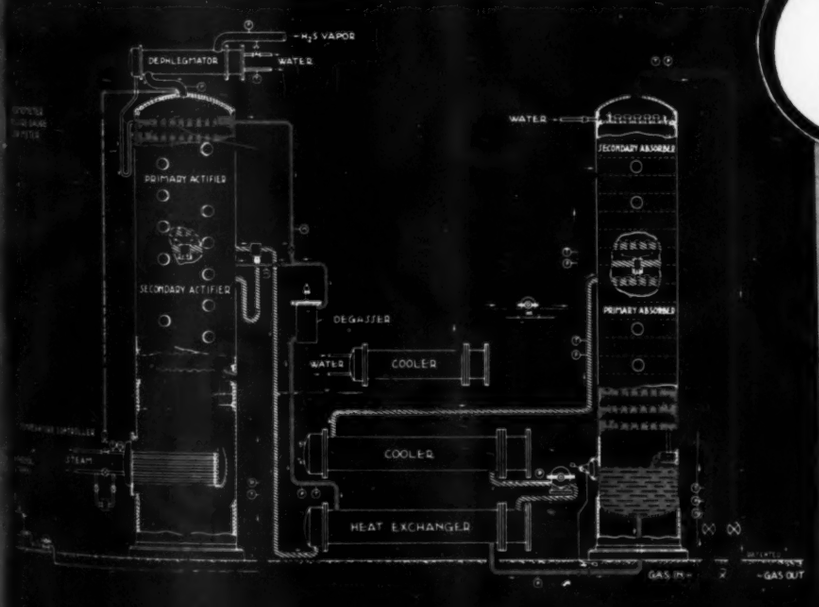

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Recent Advances in Knowledge of the Colloidal Properties of Clay Suspensions and Gels[a]

Part 2

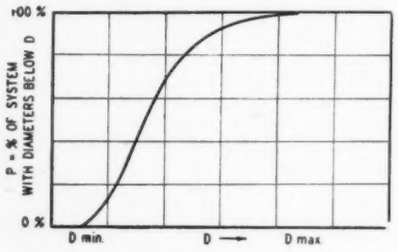
By CHARLES E. REED[b]

Particle Size and Its Distribution

ALL naturally occurring clays contain particles of different sizes. In kaolins it is usually found that 90 percent of the particles have dimensions greater than 500 mμ (1 mμ = 10^{-7} cm.) and hence can be measured directly in the ordinary microscope. In contrast, most of the particles in bentonite cannot be resolved in the ordinary microscope and indirect methods must be used to estimate the particle size.

The most convenient method of characterizing the size of small particles lies in a determination of their settling rates. A particle settling in a liquid will increase in velocity until the frictional drag exerted upon it is just equal to the force causing it to settle. In general, the greater the mass of a particle of given shape, the greater its settling velocity, while a particle of given mass will settle at different velocities, depending upon its shape. Although it is known that platelike particles of given mass settle more slowly than spherical particles of equal mass, the laws governing the sedimentation of plates are unknown and it has become customary to report a particle of any shape settling at a given rate as having an "equivalent diameter" equal to the diameter of a spherical shaped particle of the same material that will settle at the same rate. Since in general all particles of a given material are of similar shape, the concept of "equivalent spherical diameters" enables us to compare the relative size of particles.[d]

Fig. 4. Particle-size distribution



Since a sample of clay will, in general, contain particles of variable size, it is important to know the nature of the particle-size distribution; i.e., the proportions of the sample represented by particles of different sizes.[e] Particle-size distribution data may be obtained most conveniently by sedimentation methods. The particles in most clays are too small for practical separation by gravity and it is necessary to resort to centrifugal fields.[f] (Figs. 4 and 5.)

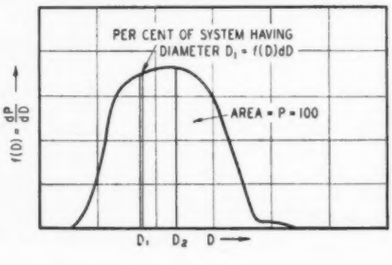
Table 1 presents size-distribution data obtained by Marshall on a kaolin and a bentonite. The coarse impurities, those about 2μ (1μ = 0.001 mm.), were removed by gravity sedimentation. The clays were purified of metals by electrodialysis and suspended in 0.2 percent Na_2CO_3.

The great difference between kaolin and bentonite is readily apparent. It is probable that the larger fractions of this bentonite are not homogeneous and that the true montmorillonite fraction with high swelling and geling properties is the finest material. Hauser and Reed have reported a complete centrifugal sedimentation analysis on a highly purified sample of Wyoming bentonite, the particle-size distribution curve of which appears in Fig. 6. The chemical analysis of this bentonite approximates the formula $Al_2O_3.4SiO_2.H_2O$ and 75 percent of the sample consists of particles with equivalent spherical diameters less than 50 mμ and a large fraction of the material below 50 mμ is relatively uniform in size.

Effect of Particle Size Upon Colloidallity

In an attempt to establish the effect of particle size upon the colloidal properties of clay suspensions and gels, a sample of Wyoming bentonite was subjected to a series of centrifugal fractionations, with the result that six particle-size fractions were obtained.

Fig. 5. Data of Fig. 4 replotted



[a]Paper presented at Oklahoma City meeting, Petroleum Division, American Institute of Mining and Metallurgical Engineers, October, 1937.

[b]Department of Chemical Engineering, Massachusetts Institute of Technology, Cambridge, Massachusetts.

[d]An additional complicating factor in the interpretation of equivalent spherical diameters comes from the fact that the velocity of a particle may vary according to the position it occupies in settling. Thus, plates will settle fastest when their long axes are parallel to the direction of sedimentation. Fortunately, the complication of this factor is reduced to a minimum in the present case, where we are dealing with plates and all sedimentations were conducted in strong centrifugal fields. Under these circumstances a force analysis on a settling plate shows that it will orient with its long axes parallel to the direction of sedimentation. Thus all plates will settle in the same relative position.

[e]The particle-size distribution of a given sample may be represented by a curve like that in Fig. 4, where the ordinate P at any point gives the percent by weight of the particles in the sample having diameters below D. Frequently the data represented by the type of curve in Fig. 4 are replotted in the form of Fig. 5. In Fig. 5, at any value of the diameter D, the corresponding ordinate is the slope of the curve in Fig. 4 at this same value of D. This slope is called the particle-size distribution function $f(D)$, and the ratio of the area bounded by any two ordinates in Fig. 5, such as D_1 and D_2, to the total area under the curve extending from the smallest to the largest particle is equal to the percent by weight of the particles in the sample having diameters between D_1 and D_2.

[f]It is without the scope of this paper to describe centrifugal methods of particle size analysis. Marshall[14] has proposed a method using the basket-type centrifuge, which is applicable to the larger particles in clays, while Hauser and Reed[8] have developed a method using the supercentrifuge, which is applicable to the finest particles. While the ultracentrifugal methods of The Svedberg[17] would be applicable to clays, the expense and complication of the apparatus required has greatly limited their adoption.

TABLE I—Size-distribution Data

Clay	1μ	1μ-500 mμ	500-200 mμ	200-100 mμ	100-50 mμ	< 50 mμ
Kaolin	58.6[a]	30.1	7.5	3.8		
Bentonite	14.6	19.5	20.6	4.0		39.3

[a]Percent by weight of sample having equivalent spherical diameters > 1μ.

The details of the fractionation procedure, which cannot be considered here, have been fully reported elsewhere.[5]

The centrifugally determined particle-size distribution curve corresponding to each of these individual fractions appears in Fig. 7. Fraction V is not shown because it is similar to VI. The distribution curves are plotted on semilog paper, which serves to indicate well the percentage variation in equivalent spherical diameter (e.s.d.) of the particles in each fraction, equal distances along the D axis indicating equal percentage variations in e.s.d. The usual distribution function ordinate $f(D)$ has been multiplied by D so that any area bounded by two ordinates under a curve on this plot has exactly the same significance as in Figs. 5 and 6. Considering the difficulties of such a fractionation the relative absence of overlap is truly remarkable.

All fractions analyzed the same chemically and approximated the formula $Al_2O_3.4SiO_2.H_2O$ and, as mentioned previously, all have the same equivalent weight of approximately 1000.

For the purpose of later plots the results are also reported in the form of average equivalent spherical diameters of each fraction. Exactly half of the fraction by weight contains particles with equivalent spherical diameter less than the average as here defined. The average e.s.d. of each of the fractions of which the distribution curve appears in Fig. 7 is as follows: fraction I, 14.3 mμ; II, 20.3; III, 28.1; IV, 33.8; V, 87.0.

Fig. 8 shows the six fractions in the form of gels as they were removed from the centrifuge bowl, fraction I, the smallest, being at the left and fraction VI, the largest, at the right. Fig. 9 shows the fractions diluted down to suspensions that had remained undisturbed for nine months at the time of this picture. The order of increasing size can easily be seen from the sedimentation as being from left to right. Fraction I turned out to be of unusual clarity while fraction VI bears more resemblance to an ordinary opaque clay suspension. When stirred, these fractions, particularly the fine ones, exhibit beautiful silky streaks, caused by the platy particles becoming oriented by the stream lines of flow in the liquid and reinforcing each other in the reflection and refraction of light.

Outstanding among the colloidal properties of interest in these systems is the rate at which a given sol will increase in viscosity and transform itself into a gel. The rate of sol-gel transformation is not only of practical moment in the control of muds, but when properly studied it may throw light upon the mechanism of gelation and the structure of the resulting gels.

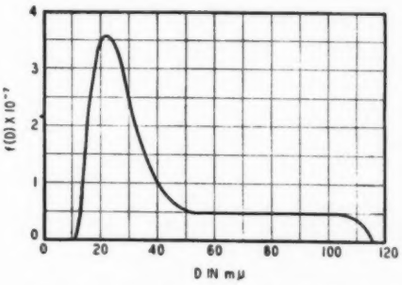
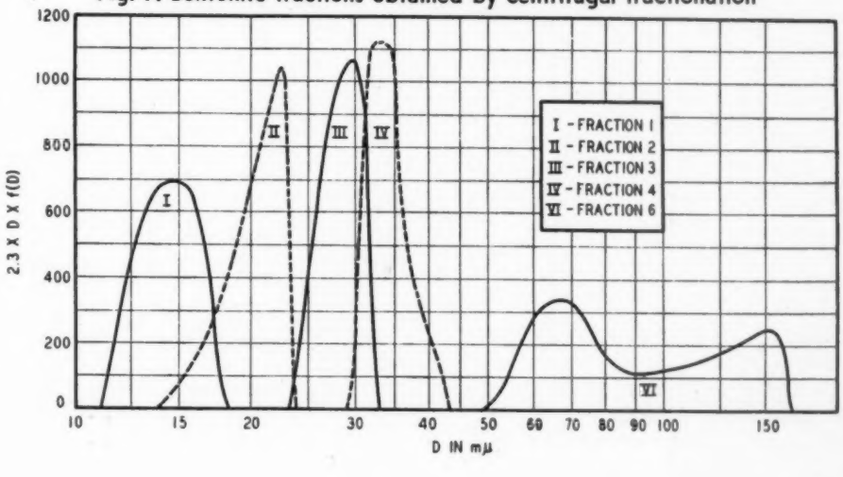


Fig. 6. Particle-size distribution of Wyoming bentonite

When a clay sol sets to a gel the mechanical properties of the gel continue to undergo a change toward some limiting value that would be approached were the gel allowed to stand indefinitely. Thus, the tensile strength of the gel, its yield point, and viscosity all increase with time as long as it is left undisturbed. As soon as the gel is disturbed, the structure being built up within it is affected and the mechanical properties all undergo a change. The difficulties, both theoretically and practically inherent in the physical measurement of any of the mechanical properties of outstanding thixotropic systems like clay suspensions and gels, have been inferred in an earlier section of this paper and are widely appreciated. Many of these difficulties are avoided if one is willing to operate under arbitrarily chosen conditions. In the present instance, it was considered satisfactory to use as a measure of gelation rate the time required for a sol to set to a gel of conveniently selected, though unknown, strength. The technique of obtaining this measurement involved the introduction of a standard quantity of clay suspension of fixed concentration into a Pyrex tube of definite diameter. By trial there was determined the elapsed time necessary before the undisturbed tube could be inverted in a standard fashion with no flow of the contents taking place down the walls. This time has been called the setting time, and its use in measuring gelation has been discussed by Squires and Broughton.[15]

Since the rate of sol-gel transformation is affected by the different ions present in the system, all fractions to be tested were purified of electrolytes by electrodialysis and a suitable amount of a standard electrolyte added. The results are given in Fig. 10, where setting time in minutes is plotted against average e.s.d. The time required to build up a gel of given strength increases enormously with an increase in particle size. It was impossible under any of the conditions represented on this plot to observe any evidences of gelation in fraction VI with average e.s.d. of 87 mμ. The standard electrolyte used in these tests was KOH, and the setting time under-

Fig. 7. Bentonite fractions obtained by centrifugal fractionation



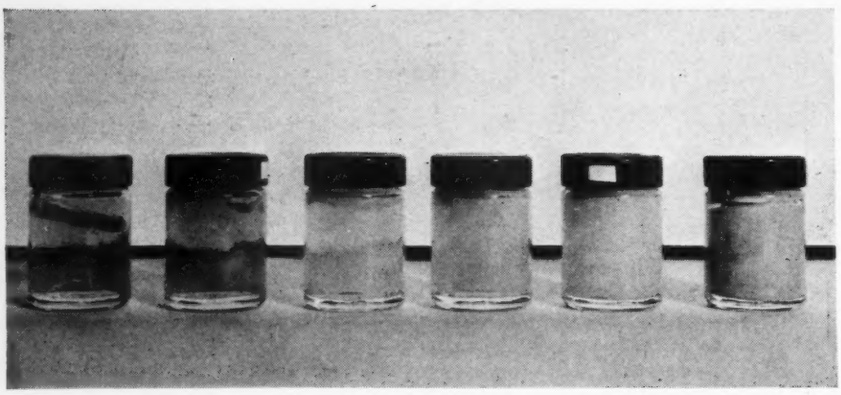


Fig. 8. Particle-size fractions coming from centrifuge bowls as gels. Increasing size from left to right

goes marked decrease with increase in KOH concentration. Similarly, by increasing the concentration of clay it is possible to decrease the setting times in every instance.

which possesses a yield point, bubbles smaller than a certain critical size will not have the buoyancy to overcome this yield point, and will remain stationary.

Fig. 9. Bentonite fractions in sedimentation for nine months

While no direct data are available with respect to the final strength of the gels reported in Fig. 10, the fact that under these conditions no evidence of structure could be detected in fraction VI makes it not improbable that, other factors being equal, the facts are that the smaller the particles in a gel of given concentration, the greater its ultimate strength. In this same connection it may be noted that the tendency of the extremely fine fraction I to gel is so great that gel structure may be readily identified at concentrations of bentonite between 0.05 and 0.1 percent by weight. The method of detecting structure at these low concentrations involves the observation of entrapped air bubbles. These will always rise in a true liquid, no matter how viscous, whereas in a gel,

The radical difference in behavior effected by particle size forces us to the conclusion that the smallest particles are primarily responsible for the gelation of clays.

Were it practical to effect a particle-size fractionation of the clays composing drilling muds, one would have available a valuable method of control over the mechanical behavior of the muds. Having once obtained the proper particle-size fractions, there is no reason why these might not be blended to give a mud of any desired characteristic.

EDITOR'S NOTE: *This article will be concluded next month.*

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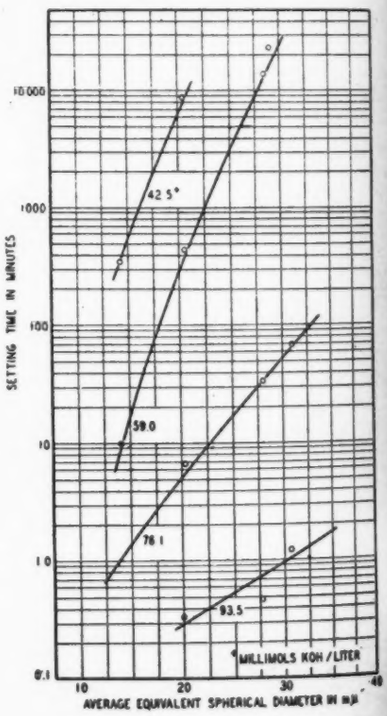
Fig. 10. Thixotropic setting time of 0.85 percent bentonite suspensions at 25 deg. centigrade



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Methods of Cementing Wells to Reduce Gas-Oil Ratio

Gas from free gas sand or upper part of oil sand can be excluded by proper application of "squeeze" cementing

By WALLACE A. SAWDON
Petroleum Engineer, Los Angeles

THE benefit derived by restricting the volume of gas produced per bbl. of oil to an amount that will coordinate efficiency of production with preservation of lifting power, future economic production, and higher ultimate yield, is recognized. The necessary control of gas-oil ratios must naturally involve conditions peculiar to a certain well or, at most, to some definite productive area. Mechanical means for restricting the quantity of gas accompanying the oil have been discussed[1] extensively. The use of acid to increase the oil flow when the action of the acid can be restricted to an oil-saturated section, the gas zone being protected, has also been described. If there is a definite separation between the oil and gas strata, however, or if the gas from the top of the sand is segregated to such an extent that it may be regarded as free gas, shutting off the gas flow at its source is generally most advantageous.

The exclusion of gas at its source has been accomplished in many wells by the use of packers or by cementing a string of casing landed below the gas-producing zone. When the casing is cemented in the ordinary manner, however, it has only the bond provided by the cement against the gas sand; frequently this bond will fail to shut off the gas unless some of the cement is forced into the formation at a pressure greater than that exerted by the gas. For this reason cementing by the squeeze method generally is necessary in order to obtain a satisfactory gas shut-off immediately above or in the upper portion of the productive stratum.

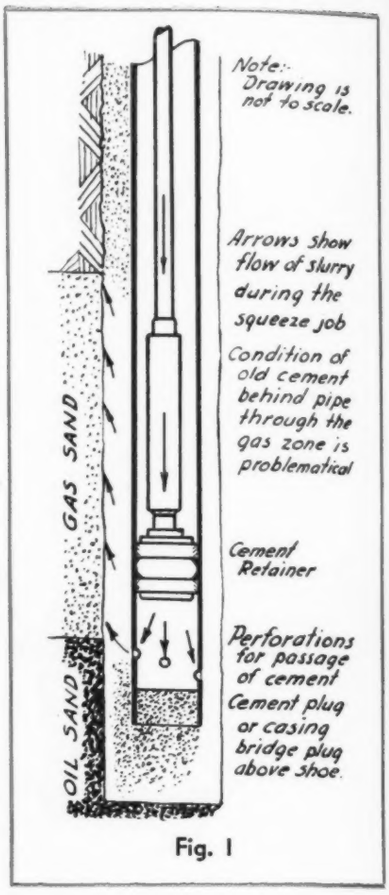
The outstanding success of cementing by the squeeze method in reducing the gas-oil ratio in several fields in the Gulf Coast area has resulted in the development of a technique applicable to the exclusion of gas from the upper part of a producing zone, whether there is a parting between the oil and gas strata or the gas is coming from the upper part of the oil zone itself. Details of the procedure followed by different companies in dealing with different subsurface conditions naturally vary. The usual practice now being followed is to place the cement through a cement retainer at pressures of 2000 to 3600 lb. per sq. in., but in at least one well, pressure as high as 5600 lb. per sq. in. was used.

The Squeeze Job

The general procedure followed in performing a squeeze job is illustrated in Fig. 1. Variations used on particular jobs are later described and illustrated to show its application in conjunction with different drilling practices and under various subsurface conditions.

The casing is usually landed below the gas-oil contact at whatever point the operator thinks desirable. This string is then cemented in the usual manner, the proper height of the cement behind the casing being determined in the same manner as in cementing any string under ordinary conditions. The usual tests are then made, including generally a production test, which gives definitely the gas-oil ratio. In some wells, however, the cement is not drilled out of the shoe but is left to form a plug at the bottom of the hole. If the cement is drilled out and a production test made, a cement plug is built up in the casing or a casing bridge plug is set just above the shoe.

Holes for passage of the cement from the casing into the formation are then perforated above the plug and as close to the bottom of the gas zone as possible, most companies making these holes just below the bottom of the gas-producing zone. A cement retainer is then run in on tubing (or on drill pipe if circumstances warrant its use) and set to pack off just above the perforations. Above the retainer is placed a circulation joint, which serves as a valve that is opened or closed by lowering or raising the pipe on which it is run. Its use allows the bleeding of fluid from the drill pipe or tubing into the casing when desired. The retainer is also equipped with a back-pressure valve, which prevents cement coming back into the pipe after it has passed through the retainer, and which maintains the pressure on the cement after it has been forced into the formation.


Note:- Drawing is not to scale.
Arrows show flow of slurry during the squeeze job
Condition of old cement behind pipe through the gas zone is problematical
GAS SAND
Cement Retainer
Perforations for passage of cement
Cement plug or casing bridge plug above shoe
OIL SAND
Fig. 1

It has been found advisable to pump clear water into the formation in order to measure the pressure at which the formation will take fluid. An estimate of the amount of cement the sand will take, the pressure that must be applied, and the kind of cement best suited to the job can then be made. The bottom-hole temperature influences the operation, because cement will set faster at high temperature.

The pressure required to force water

(Continued on page 70)

[1] "Gas-Oil Ratio Control in Flowing Wells," by R. J. Sullivan, presented at eighteenth annual meeting, A.P.I., November 12, 1937, and abstracted in the November, 1937, issue of *The Petroleum Engineer*.

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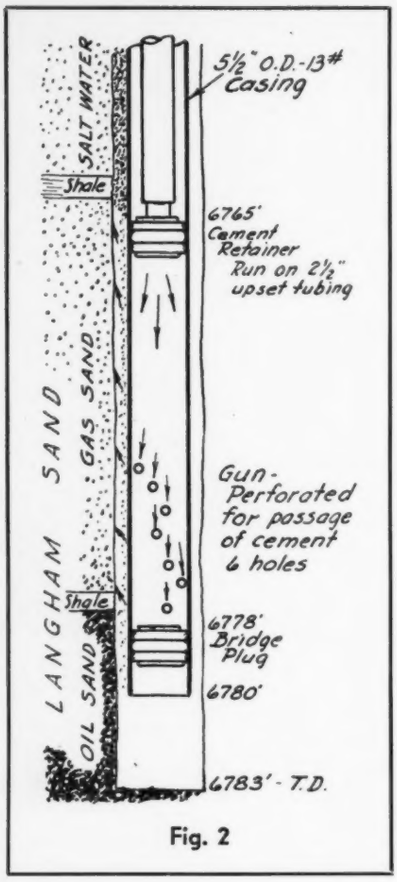


Fig. 2

(Continued from page 66)

into the formation is the governing factor in the selection of the cement and in the determination of the mix to use. If the formation will not take water at a pressure less than 2500 lb. per sq. in., a thin slurry of slow-setting cement is considered necessary in order that sufficient cement may be forced into the formation to shut off the gas. This slow-setting cement generally is followed by regular cement, which will set more quickly on entering the formation; the pressure data also determine the amount of regular cement that will be required for the job.

If the pressure required to make the formation take clear water is lower, say 1500 lb. per sq. in., and drops to 800 or 1000 lb. after 10 to 20 bbl. of water has been introduced, the formation will take ample cement and the regular kind of cement can be employed if the bottom-hole temperature is normal.

The behavior of slow-setting cement and its advantages in squeeze jobs have been discussed in detail.[2] It is stated that "When the pressure is high, it is better to begin by pumping in a light slurry weighing 12½ or 13 lb. per gal. in order that the free water in the slurry may carry some of the 'fines' or 'flower' of the cement with it into the formation to give support to the cement that is strained, or filtered, out to form a sheath on the face of the sand exposed in the hole. Though the ultimate quantity of cement on the face of the sand will be the same, prolonging the process of injection will allow free water in the cement a better opportunity to carry some of the 'fines' into the formation with it."

The cementing operation consists of pumping the cement down the tubing, through the cement retainer and perforations, and into the formation. If the casing previously has been cemented in the ordinary manner, there is no circulation and the squeezed cement must pass between the old cement and the face of the gas sand, where it is forced into the sand face under a pressure higher than the pressure exerted by the gas itself. It forms a sheath on the sand and, insofar as can be judged from results, makes a bond between this sheath and the cement behind the pipe.

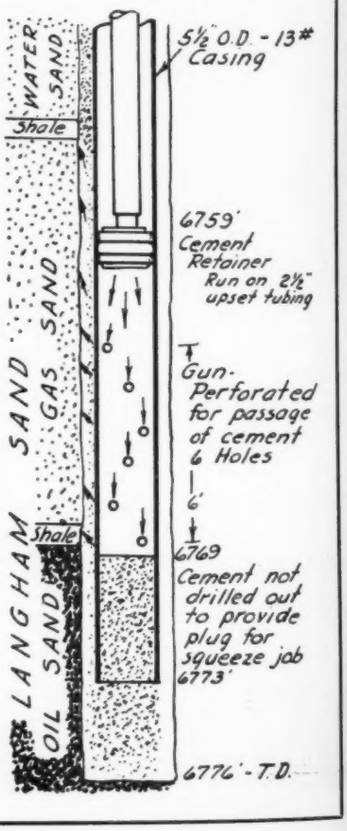
Examples of Squeeze Jobs

In the Amelia field in Texas there are small shale breaks between the oil and gas sands. The wells are cored and checked with electrical logs during drilling so that the casing can be set through the gas sand and this zone cemented off behind the pipe. Originally it was the custom to run the liner and to put the well on production and then to perform a squeeze job if the gas-oil ratio was found to be high. As development of the field progressed the geologist could predict when a squeeze job would be necessary and it was done before the liner was run. Two wells are cited to show the practices followed, the second illustration giving the procedure when conditions are known before setting the casing. Details of setting the liner and completion after the squeeze jobs are not given.

The well illustrated in Fig. 2 was making 105 bbl. per day of 29-deg. A.P.I. oil and had a gas-oil ratio of 26,300 cu. ft. per bbl. under the conditions shown in the drawing. A cement retainer was set as a casing bridge plug at 6778 ft. and above it six ½-in. holes were gun-perforated in the casing between 6774 ft. and 6778 feet. Another cement retainer was then set at 6765 ft. and the formation tested with water. It took the fluid at a pressure of 1800 lb. per sq. in., ten bbl. of water being pumped in ahead of the cement. A 50-sack batch of cement was mixed in proportions of 15 lb. per gallon. Twenty sacks of cement was put into the formation under a final pressure of 2800 lb. and the rest was flushed out of the tubing by opening the circulation joint and reversing circulation. The cement and retainers in the casing were drilled out and the well completed. It produced at the rate of 612 bbl. of oil per day and at a gas-oil ratio of 366 cu. ft. per barrel.

When conditions are known, the procedure shown in Fig. 3 is followed. After the casing in this well had stood cemented for the required length of time, the cement was drilled out to a point above the top of the shoe. Six holes were then perforated in the casing above the plug thus left and a retainer was set at 6759 feet. The formation took water at first at a pressure of 2500 lb. per sq. in. and later at a pressure of 1800 pounds. Ten bbl. of water was introduced before the batch of 75 sacks of cement, of which 43 sacks was forced into the formation at a final pressure of 3400 lb. per sq. inch. The circulation was reversed

Fig. 3



[2] "Influence of Controlled Cement Slurry Weights in Squeeze Jobs," by Jack Barnes, *The Petroleum Engineer*, August, 1937.

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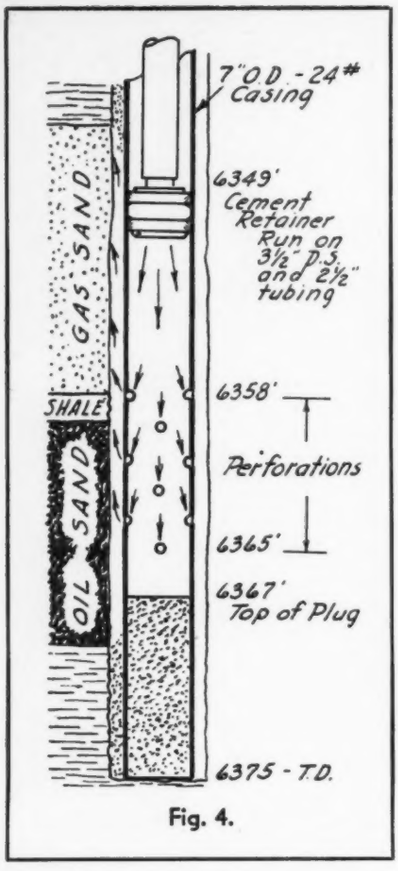


Fig. 4.

and the remaining cement pumped out. The well was then completed and produced at the rate of 656 bbl. per day of 29-deg. A.P.I. oil, the gas-oil ratio being 466 cu. ft. per barrel.

In the Lockridge field a 4-ft. shale break separates the oil sand from the overlying 40-ft. gas sand. Fig. 4 shows a well that had a gas-oil ratio of 25,000 cu. ft. per bbl. when completed. A batch of 50 sacks of four-hour (slow-setting) cement was pumped into the formation under a pressure of 2650 lb. per sq. in., and this was followed by 25 sacks of regular cement. Only 17 sacks of the latter had entered the formation when the pressure reached 3350 lb., but this was considered sufficient, so the circulation joint was opened and the rest circulated out of the drill stem and tubing. When the well was put back on production the gas-oil ratio was 400 cu. ft. per bbl. and the rate of oil production was 235 bbl. per day through a ¼-in. choke. Pressure on the tubing was 150 lb. and on the casing, 600 pounds.

In this field it has been found that some of the wells readily produce oil through the perforations used for squeezing the cement into the formation. Supposedly cement will not set on the face of an oil sand, and this contention has been substantiated by the results of some squeeze jobs made in open hole to shut off water entering below an oil sand. Evidently this is assumed to be true by the writer of the article mentioned.[2]

One company prefers to drill through the sand and test production through the drill pipe. Casing is landed on bottom and the well is then cemented through perforations near the shoe, the cement being carried up behind the casing to a point above the top of the sand. Perforations for production are then made opposite the oil sand. If the gas-oil ratio is still too high, a second squeeze job is performed.

Fig. 5, showing a well in the Dickinson field, indicates another variation.

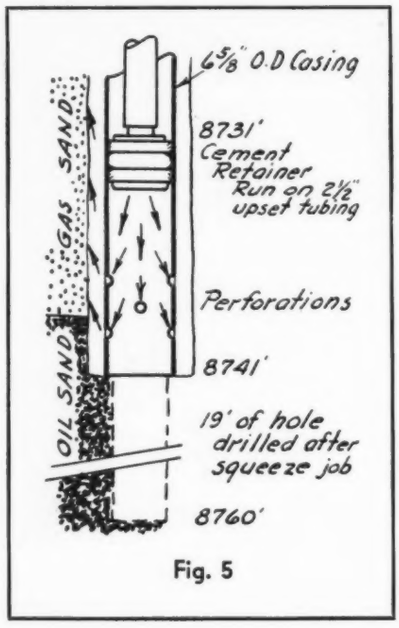


Fig. 5

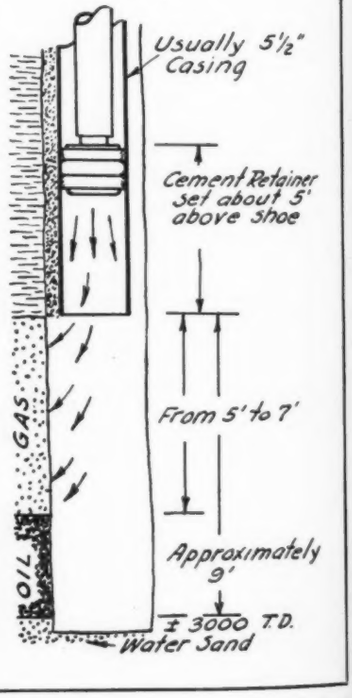
Before the squeeze job was performed the gas-oil ratio of this well was 16,000 cu. ft. per barrel. Although a pressure of 4000 lb. was applied for 15 minutes, the formation would not take fluid. The mud was made heavier and at 3800 lb. per sq. in. the formation took water. After pumping in 15 bbl. of water the pressure dropped to 1500 lb. and 50 sacks of cement was put in, the final pressure being 2300 pounds. The hole was then drilled out and deepened 19 ft. whereupon it produced at the rate of 715 bbl. per day of 39.5-deg. A.P.I. oil through a ¼-in. choke at a gas-oil ratio of 641 cu. ft. per barrel.

The first wells drilled in the Corpus Christi area blew in, making nothing but gas. After the gas had been killed with water 25 sacks of cement was squeezed in at a pressure of 3000 lb. per sq. inch. The current practice is to drill, set pipe, and test. In drilling, the sand is cored and when water is reached, drilling is stopped.

General conditions are shown in Fig. 6. Water at a pressure of 500 to 1500 lb. per sq. in. is pumped into the formation until it enters at a steady pressure. The quantity of water so introduced varies from 5 to 40 bbl. but the average is ten barrels. Then 25 sacks of cement is pumped in at a pressure that does not exceed 2000 pounds. If the sand will not take water it is assumed that the gas sand has been cemented off. If the pressure does not rise, the operation must be repeated. The well is tested after four hours and if water still can be pumped into the formation another 25 sacks of cement is squeezed in. If the pressure is high it is maintained for ten minutes.

Wells in other fields throughout the Gulf Coast area are being cemented in a similar manner to reduce the gas-oil ratio. Many unusual conditions have necessitated special adaptations of the cement squeeze job in specific wells. There are problems in gas exclusion that have not been overcome but the success achieved using the squeeze method of cementing warrants its due consideration before trying some other procedure.

Fig. 6



A general view of the pipe-bending rig. The two men in the center are taking up on the winch, thus causing the heated section to wrinkle

Wrinkle-Bending on Pipe Lines

Process, although employed for a number of years, only recently has come into widespread use — Details of wrinkle-bending procedure.

A RELATIVELY new method for bending pipe has been developed that promises considerable economy in the field fabrication of overland pipe lines. This method, known as "wrinkle-bending," consists in heating with the oxy-acetylene flame one or more narrow bands at right angles to the pipe and extending about half-way around the pipe. The pipe is then bent either by hand or by means of a tractor or bending rig until the heated sections buckle sufficiently to give the pipe the desired curvature. Although the process has been known and practiced for more than a quarter of a century, it is only recently that its use has become widespread, and it is thought that a detailed description of the wrinkle-bending procedure at this time should prove valuable to pipe line contractors and others who may not be familiar with the many advantages and economies of the process.

Wrinkle-bending is analogous to shop-fabricated creased bends, but the wrinkle or crease is not so pronounced. As a rule, each wrinkle is used to produce only a slight change in direction of the pipe. When the bend is more pronounced a series of wrinkles are used to give an easy flow, long-sweep bend. The wrinkles project outward, thus providing a full opening throughout the bend. The method has found its greatest favor in mountainous country where, obviously, the greatest amount of bending is necessary, and where cold bending is difficult because of the rough terrain and the heavy equipment required.

Wrinkle-bending is applicable to small- and large-diameter pipe alike. Excellent results have been obtained on 4-in. and 6-in. pipe and equally good results have been obtained on the larger sizes, up to 22-inch. The method is adaptable to both heavy-wall and light-wall pipe and can be performed in the shop as easily as it can in the field.

The advantages of wrinkle-bending are numerous. Especially important is the fact that the pipe wall is never thinned from the original thickness. On the contrary, because of compression the metal at the wrinkle is actually slightly thicker than the original wall. The metal on the outside of the bend opposite the wrinkle retains its original thickness.

Wrinkle-bending lends itself readily to correction, as too much bending in one or more wrinkles may be corrected simply by reheating and applying a reverse pull or sag. Furthermore, the pipe is not strained as in cold bending because the bend takes place only at the point where the steel has been softened by heating. The facility with which bends are formed permits ready fabrication of gradual or long-sweep bends that are so desirable in overland pipe-line construction.

Another important feature of wrinkle-bending is its low cost. Equipment cost, labor cost, and materials cost are all low. Also, the method permits bending even before the ditch is cut. Wrinkle-bending fits in well with the all-position or stab-on methods of welding.

Even 180-deg. bends are readily made by wrinkle-bending. These may be made in the shop and then fitted on the job. Pumping station piping equip-

Preparatory to bending pipe, two operators heat a narrow band at right angles to the pipe

The near bend in this section has two wrinkles; the far bend four

ment is an example of this type of work.

If the terrain is rough and the pipe size large, wrinkle-bending can be done at the railroad siding where the pipe is being unloaded. The bent sections are then hauled by the pipe-stringing trucks and placed where needed. This procedure is of special value in composite construction.

As a rule, only one oxy-acetylene blowpipe is required for pipe of less than 6-in. diameter. The large capacity blowpipes designed for heavy heating operations are particularly suitable for wrinkle-bending. Additional equipment consists of a manifolded supply of dissolved acetylene, or an acetylene generator, and a supply of oxygen. Usually, both gases are hauled along the right-of-way on a sled. Trained welding operators are not required, as the process involves only a simple heating operation.

In field fabrication, the bending or laying foreman decides where a bend is necessary. This may be a side bend, sag bend, or overbend. If the pipe is of small diameter, 6-in. for instance, no additional bending equipment is necessary. The section of pipe is laid above the ditch on skids and the foreman marks the point at which the pipe is to be bent. The workmen handling the heating apparatus stand on each side of the pipe, then proceed to apply heat at this point to one-half or two-thirds of the upper circumference of the pipe. The band of heat should be two to three in. wide at the top of the pipe and should taper down to zero on the two sides. The pipe should be heated to a bright red color.

When the pipe reaches the correct temperature, the section should be rolled over quickly so that the heated portion is on the underside. At the same time, one of the pipe gang should throw the skid on which one end of the pipe is resting into the ditch. This workman should then press, if necessary, on his end of the pipe while the other end is held securely by two other workmen. The weight of the pipe itself usually is sufficient to form the wrinkle, and the workman in the ditch often finds that his chief task is to hold the sagging pipe to the requirements of the bend.

This operation is repeated until enough wrinkles have been formed to give the required bend. In general, five to seven deg. is the maximum angle to which the pipe should be bent. A greater total bend is obtained by using more wrinkles. Wrinkles may be spaced at any distance, depending on the angle of the bend and the diameter of the pipe, but it is more desirable to produce long sweeps wherever possible rather than abrupt bends.

The entire procedure should not require more than two and one-half to three minutes. All three types of bend, sag, side, and overbend, may be produced readily in one section of pipe.

Thirteen wrinkles were required to give this pipe section its total bend of 35 degrees

Two blowpipes should be used for heating pipe of 6-in. diameter and larger. Also, additional bending equipment is necessary if the pipe is large or is lying alongside the ditch or on the ground prior to ditching. A tractor, A-frame, or bending rig can be used. If a tractor is used, it should be equipped with a stiff leg. The tractor should run part way onto the timbers that hold the pipe in place, the stiff leg set in position, and the chain block attached. The chain block in turn is

The wrinkles in this 12-in. diameter pipe are spaced at intervals of 10 in., each wrinkle averaging a 2- to 3-deg. bend

An angle-finder assures that the bend in the pipe conforms with the angle of the ditch

fastened to the pipe. The pipe should then be heated in the usual manner with the two blowpipes and, when the proper temperature is reached, the free end should be pulled upward by means of the chain block.

Another method for performing this type of work is to use a tripod or A-frame equipped with block and tackle. One end of the pipe should be anchored temporarily, the heat applied, and the free end then hoisted to form the wrinkle. Still another method using the same equipment is to hoist the pipe first, place one or two men at one end to steady the pipe, and one or two men at the other end to press down. Heat is then applied on the underside of the section, and the wrinkle is formed by the weight of the sagging pipe.

If the pipe is the usual low-carbon type, the bend can be arrested at any time by sudden cooling with water; however, this practice is not recommended for high-strength pipe. In wrinkle-bending longitudinally-welded pipe, the heat preferably should be applied 180 deg. from the seam.

When a small angle is required, the wrinkle need not extend half of the circumference. The flexibility of the process permits the foreman to put in just the right amount of bend at just the right places.

The accompanying illustrations were taken on a 45-mile natural gas line in West Virginia. Because of the extremely mountainous country, the interval between bends in this 12-in. diameter line averaged 60 ft., and an average of three wrinkles was required for each bend.

Two bending gangs worked on this line and each consisted of eight men, as follows: one foreman, two heaters, four set-up men or riggers, and one teamster. The foreman has charge of the work and sees that the required bends are made properly. The teamster, with a team of horses, hauls the pipe into convenient position for bending and also hauls the oxygen and acetylene cylinders along the line. The riggers handle the bending rig and two workmen operate the blowpipes used for heating the pipe.

One of the illustrations shows the type of pipe-bending rig used on this line. A stiff leg with a saddle is attached to one end of the pipe by a chain and to the other end by a cable. The cable passes through a pulley and around a winch secured to the stiff leg. In this particular illustration the foreman has just indicated that the pipe is at the proper bending temperature and the two men just behind the heater in the foreground are beginning to take up on the winch. The ends of the pipe are thus drawn out of line sufficiently to produce the desired wrinkle, Additional wrinkles are then made to give the pipe its total required bend.

Simplified Automatic Combustion Control for the Refinery

By W. F. SCHAPHORST

THE accompanying sketches show a practical, simplified method for automatically regulating valves, dampers, fans, etc., to maintain constant boiler pressure.

Fig. 1 is a general view showing the sensitive regulator, which virtually "weighs" the steam pressure in the boiler. When the pressure rises too high a plunger immediately moves upward and automatically adjusts the damper, shown in the sketch, and the gas control valve, the illustrated boiler being fired with natural gas. Note the "weighted lever valve" on the gas line, which is ideal for the purpose, making operation certain in both directions. The weight closes the valve when the regulator plunger rises. As soon as the steam pressure drops the regulator plunger moves downward and re-opens the gas control valve and the damper.

Now, for an oil-fired boiler, let us substitute Fig. 2 for the lower portion of Fig. 1. This gives us an excellent arrangement for controlling an oil-fired boiler with steam atomizing, the oil control and steam-atomizing control valves being operated simultaneously by the same weight and by the same chain to the regulator.

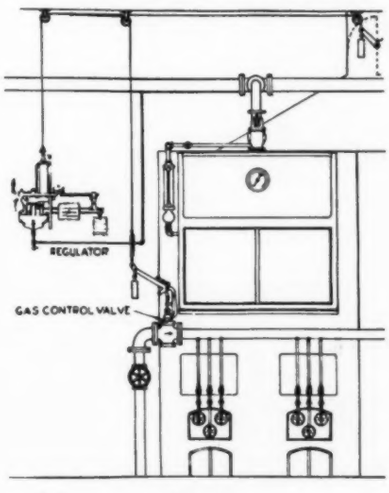


Fig. 1

This method is applicable to high-pressure or low-pressure boilers and is particularly valuable on low-pressure boilers in which the pressure is too low for assured self-manipulated control. The regulator shown here is hydraulically operated and is not dependent upon steam pressure. Additional electric motor control actuated by boiler pressure is unnecessary.

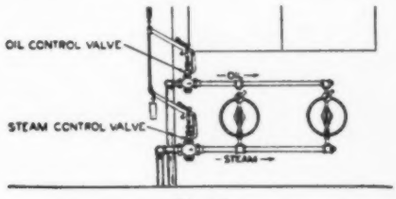
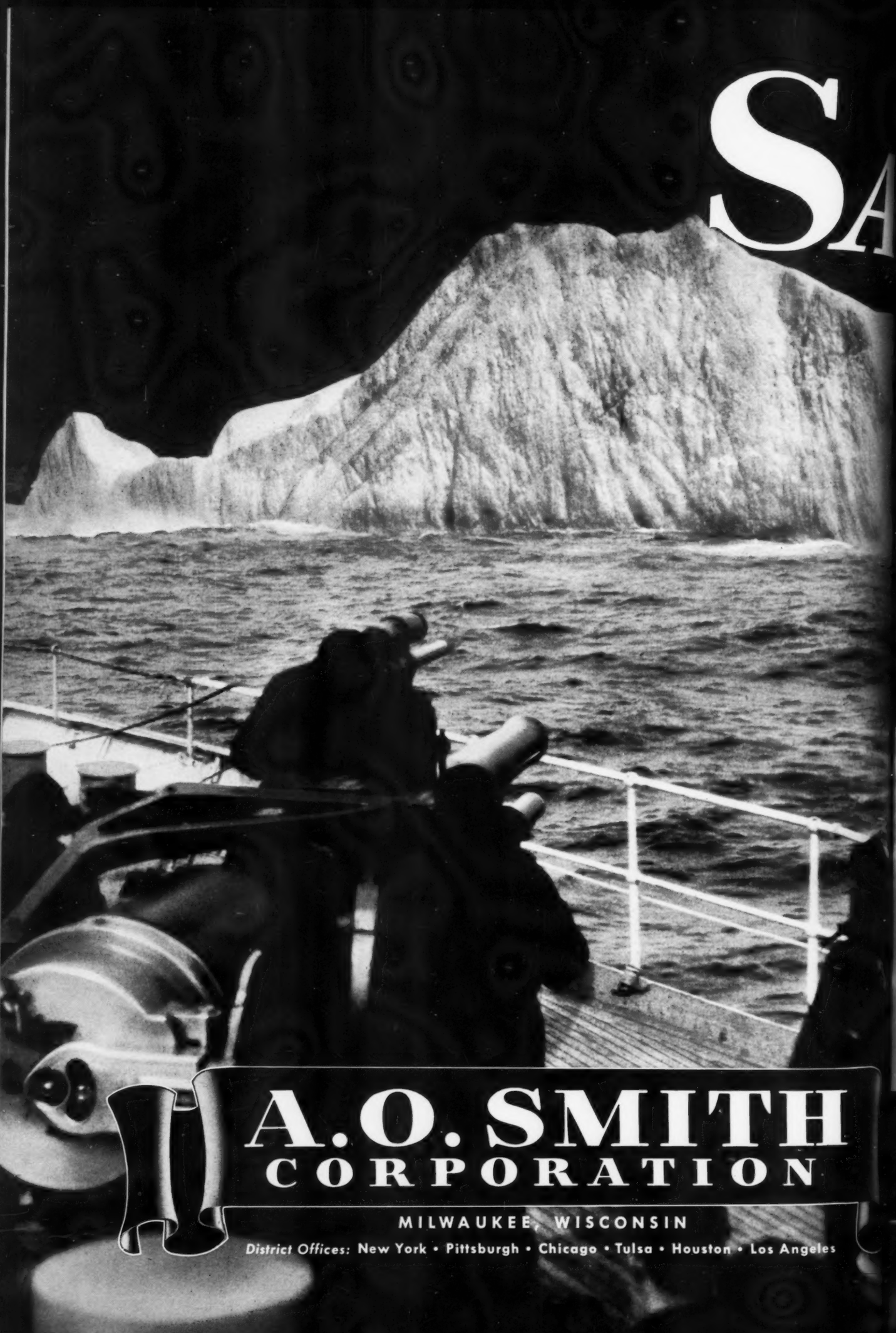


Fig. 2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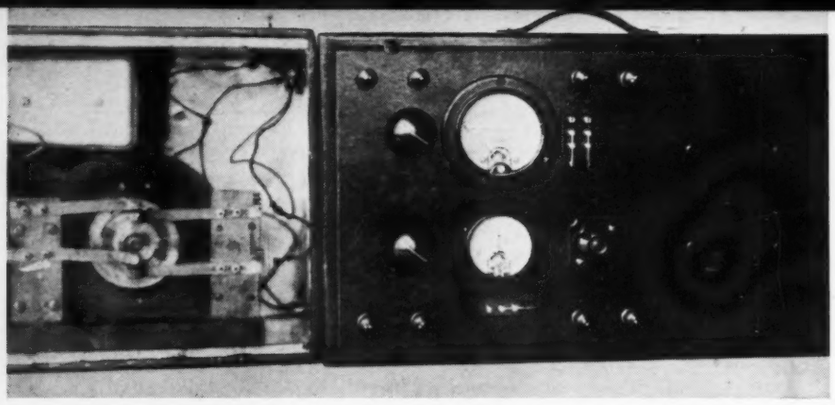

Generator, commutator, motor, rheostat, etc., used in making soil resistivity tests, are mounted in this box for portability

Testing Resistivity of Soil

Modification of field equipment has contributed to the simplification and ease of construction and operation of apparatus needed for such work

By ROBERT L. CRAIG

IN carrying on studies of the earth's resistivities a systematic arrangement of the electrodes is made. Differences of potential existing between certain of these electrodes when known currents are introduced at two of them are determined. Calculations then follow in terms of the current introduced, the resulting potential, and the spacing of the electrodes.

The Wenner configuration of electrodes is one of the most familiar. The four electrodes A, B, C, and D are collinear and equally spaced. The current I is introduced at the stakes A and D. The difference of potential V between the stakes B and C, as a result of the current I, is measured. (Fig. 1). The apparent specific resistance of the section of the earth included between the inner electrodes can be calculated by the formula:

$$\rho_a = \frac{2\pi a\, V}{I}$$

where:

a = the electrode spacing.

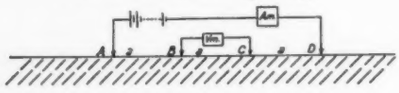

Fig. 1

The Lee configuration is similar to Wenner's. A third electrode placed midway between the two potential electrodes B and C permits measurement of differences of potential between B and E and between E and D (Fig. 2). The equation:

$$\rho_a = \frac{4\pi a\, V}{I}$$

will give the value of the resistivity in either direction from the center. V

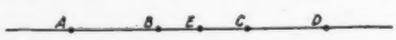

Fig. 2

will have a value about half that of V of the Wenner method.

A one-electrode configuration is sometimes used. The current electrodes A and D are separated by a great but fixed distance. The potential distribution about a current electrode then can be considered as due to that current electrode only. The potential is then measured at points along the circumference of a circle drawn about the far current electrode as a center. If the distance from the current electrode near which potential measurements are made is small compared to the distance between the current electrodes the line of potential determinations can be at right angles to the current line. It is convenient to move the potential stakes so that the distance between D and B is the same as the distance between B and C. (Fig. 3). If this distance is

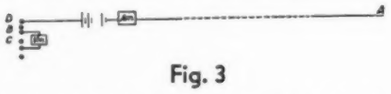

Fig. 3

called "a" the apparent resistivity between the potential electrodes can be calculated from the formula:

$$\rho_a = \frac{4\pi a\, V}{I}$$

A configuration of electrodes similar to that of Wenner's method sometimes is used. The current electrodes A and D are fixed and the inner electrodes B and C are moved away from one of the current electrodes. (Fig. 4).

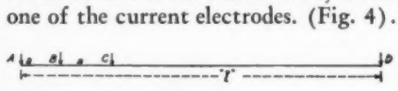

Fig. 4

The apparent resistivity is then given by the formula:

$$\rho_a = \frac{2\pi\, V}{I}\left[\frac{2a(l-a)\,(l-2a)}{(l-2a)^2 + al}\right]$$

where

l = the distance between the current electrodes

a = the interval between the potential electrodes.

The distance between the near current stake and the first potential stake also is a. This expression reduces to Wenner's formula when $l = 3a$.

Comparison of D-C. and Commutator Methods

The question of a choice of d-c. or a-c. methods arises early in the problem of earth-resistivity methods. The mathematical theory has been developed for the former; but if the same theory can be applied to data taken by a commutated-rectified method certain simplification of field equipment is possible.

It is necessary to avoid polarization at the potential electrodes. In d-c. work this is done by placing porous porcelain pots in the earth. These are filled with copper sulphate solution. The metal electrode is then put in the solution. Dr. R. J. Watson[1] describes this arrangement in discussing his small-scale work. He has used similar but large-scale equipment in field tests.

Hotchkiss, Rooney, and Fisher[2], Wilcox and Schwartz[3] and Hawkins[4] extensively report work that has been done with a cylindrical type commutator to alternate a direct current. In their experiments a potentiometer is used to measure the rectified e.m.f. brought from the potential stakes. This rectification is accomplished by a similar set of segments on the same shaft.

Cragmile, Kelly, and Low[5], Hubbert[6], and Lee[7] have described considerable work with the megger. In this instrument the ratio of the potential between the inner stakes and the current supplied to the current leads is read directly in ohms.

The writer has performed sufficient small scale and field experiments with commutator potentiometer equipment to feel confident that polarization is satisfactorily eliminated. The greater speed at which steel stakes can be

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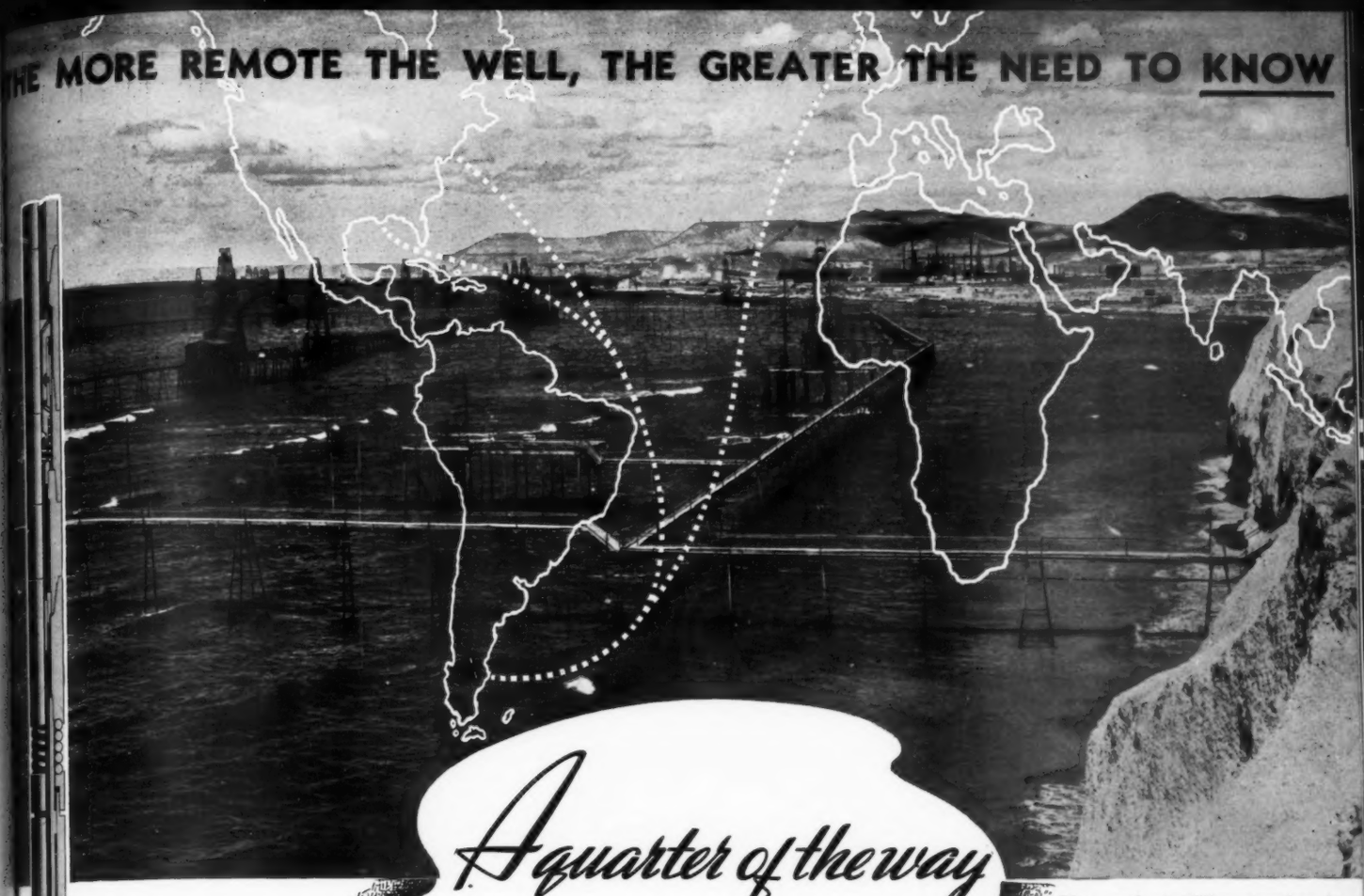

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WHY SET CASING BEFORE YOU KNOW?

driven into and removed from the earth as compared to sinking porous pots and pouring copper sulphate solution is one advanage in favor of the commutator equipment.

Reports of experimental work with the porous pots, Gish and Rooney, and megger methods over the same area do not agree. In general the shapes of the resistivity vs. electrode spacing curves are the same, but the numerical values of the resistivity are higher by the porous pot method. Calculations from data taken with the commutator-potentiometer equipment give values above the results obtained with the megger.

Interpretation: Mathematical and Empirical

In the early work with the resistivity methods the experimenters recognized that a formula such as $\rho=2a\mathrm{V}/\mathrm{I}$ was based on the assumption of a homogeneous material. In the cases of non-homogeneity the calculation by the formula gave a general average in which the top stratum, i.e., the one enclosing the electrodes, had the greatest influence. They neglected the influence of materials beyond a depth equal to the electrode spacing. Consider a case in which the first stratum has a depth of 25 feet. Assume that readings are taken at intervals of five feet. When a curve of resistivity vs. electrode spacing is plotted the curve will be a straight line for the first 25 feet. At this point the curve will bend downward or upward, depending on whether the new stratum has a lesser or greater specific resistance.

The theoretical and small scale work of Watson[1] has shown that this simple empirical rule cannot be used for depth determinations. The new stratum will have an influence long before a spacing equal to the depth to the stratum has been reached; and its influence will be effective even after the electrode spacing has been increased beyond the depth to this stratum.

The more scientific methods applicable to the data obtained over an area shown by preliminary investigation to consist of parallel strata are mainly of two types. The one, introduced by Tagg[8], is applicable to two-layer problems and certain types of more involved problems. The other method involves a comparison of the field resistivity curves with curves computed for ideal cases. Roman[9] has worked extensively in this field.

The more exact mathematical calculations permissible under rather simple conditions yield valuable information about depths to new strata; but when the underground conditions are unusually complicated, and the mathematical method cannot be used, empirical determinations may be helpful. Some control of the results must be obtained from knowledge of the local geology, well logs, etc. The resistivity field equipment also offers a means of rapidly procuring information of a qualitative nature. Such an investigation frequently is referred to as a step traverse. The electrode spacing interval is fixed and the electrodes are moved ahead progressively. The presence of a high-resistance medium between the potential electrodes will be manifested by a sharp increase in the apparent resistivity. The graph is made of the resistivity vs. the station at which the data is obtained.

Uses, Construction, and Advantages of a New Type of Commutator

It is the purpose of this article to discuss briefly the usual field equipment needed for resistivity work and to describe some modifications that contribute to the simplification and ease of construction and operation of such equipment, and reduce its cost.

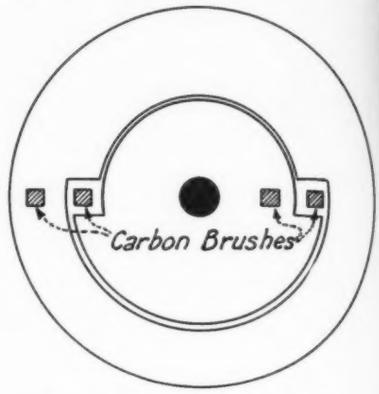
The usual field equipment for resistivity work consists of a source of direct current, a means of alternating this current, a milliammeter for measuring the magnitude of this current, a means of rectifying the current taken from the potential leads, a potentiometer, a galvanometer, auxiliary resistances, wires, and stakes. Sometimes the current and voltage measuring instruments are embodied in a single instrument called the megger; but this equipment is not essentially different from that enumerated.

B-batteries are commonly used as the source of high voltage, low amperage current. These are heavy to transport in the field. Three or more batteries may be needed to supply the voltage needed in certain regions; and the batteries do not last indefinitely.

In the field equipment discussed here the B-batteries have been replaced by a magneto-type generator. This particular one measures 5½ by 3½ by 3 inches. It draws four to five amperes of current when operating from a 6-volt battery. It generates 250 volts. Ordinarily currents of 50 or 60 milliamperes are used. On certain occasions a current of 90 or 100 milliamperes has been drawn for short intervals with no apparent damage to the generator.

Commutators used by Wilcox and Schwartz and Hawkins are similar to the one used by Gish and Rooney in their original experiments. They consist of two similar sets of cylindrical segments mounted on an insulated shaft. The writer has experimented with a similar commutator but has decided that one of a disk type offers certain advantages.

One set of brass commutator segments is shown in an accompanying diagram. (Fig. 5). A similar set is



Disk-type Commutator

Fig. 5

mounted on the other side of a fiber disk. The disk is 2⅝ in. in diameter and ⅜ in. thick. The commutator is driven by a 6-volt motor. Carbon brushes are used for both d-c. and a-c. contacts with the commutator surfaces. A small coil spring at the base of the brush, which is mounted in a square brass guiding sleeve, assures a firm contact between the carbon and the brass. These sleeves are held in position by brass strips extending from wooden uprights. The details of the mounting are shown clearly in an accompanying photograph. The generator, commutator and motor are mounted in a box 10 by 10 by 8 inches. This box also contains a two-ohm rheostat for controlling the speed of the commutator. Contacts with the stakes and potentiometer are made through binding posts on the box. Connections are completed from the bases of these binding posts to the commutator brushes. One set of bindings serves to connect the six-volt battery. Two toggle switches enable the motors to be operated separately. In most tests connections can be made directly to the battery in the car used for transporting the men and equipment.

It is believed that less difficulty is experienced in obtaining the proper alignment of the brushes in a commutator of this type. Probably the efficiency of the system is greater since there is less friction at the contacts.

The ratio of the current through a non-inductive resistance with the commutator alternately stationary and running constitutes the commutator factor. This has been found to be slightly less than 1.2 for frequencies of 7 to 70 cycles per second with currents of 20 to 70 milliamperes. The value of

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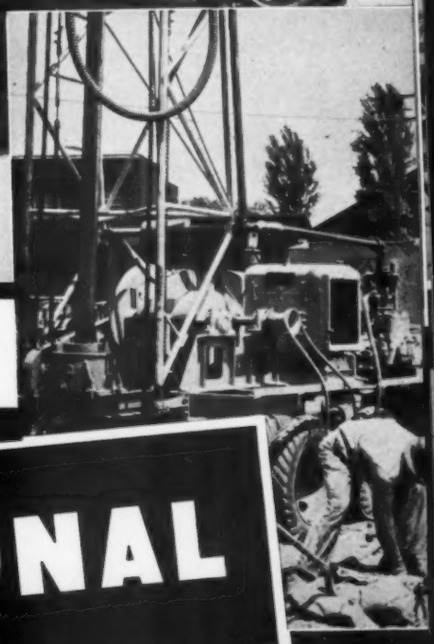

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the commutator factor as calculated from the lengths of the conducting and insulating sectors and the bearing surface of the brushes agrees with this value.

The apparatus described up to this point was used regularly during the summer of 1935 on work done for the Soil Conservation Service. The area investigated was situated in the vicinity of Pullman, Washington, and Moscow, Idaho. A student's potentiometer, a portable galvanometer, a 0-100 range milliammeter, resistance boxes, a wire rheostat, a 20 mfd. condenser, batteries, wire, stakes, and battern clips completed the equipment. These instruments, resistances, and condenser were mounted separately and consequently were somewhat troublesome to handle in a field experiment.

During the past winter several parts of the equipment have been assembled in a single case. (Fig. 6). The magnitude of the current sent into the ground is controlled by a 0-10,000 ohm rheostat. This replaces a slide wire rheostat of similar resistance but of greater dimensions.

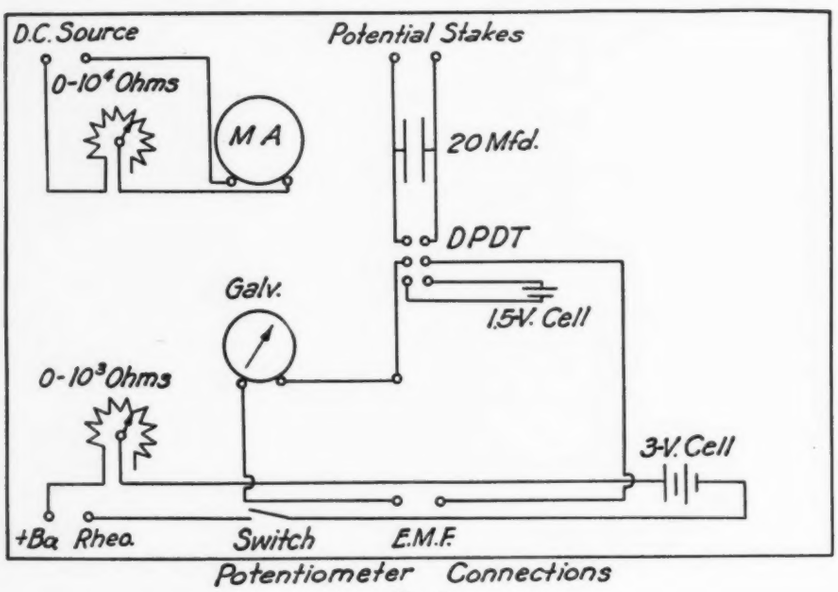

Fig. 6

Three batteries are included in the right-hand portion of the case. One serves as a standard cell. The others are the working cells. The portable galvanometer has been replaced by a panel instrument. The sensitivity of seven microamperes per scale division has proved to be sufficient for most work. The balance of the standard cell is procured by means of a 0-1000 ohm rheostat. This has replaced a plug-type resistance box.

A 20 mfd. electrolytic condenser across the potentiometer leads from the commutator is included in the case. It replaces a bank of paper condensers. The ten condensers needed to give the equivalent capacity filled a 9-in. by 6-in. by 5-in. box. The electrolytic condenser serves to steady the galvanometer readings as effectively as did the other one and it is certainly more compact.

As previously mentioned the equipment has been subjected to considerable field use. Sufficient rubber-covered stranded copper wire is available to permit electrode spacing of 360 feet. A four-man party has been able to make four tests of that extent in an eight-hour day. The time included that required to drive to and from the field. As a rule the spacing was increased by 5-ft. intervals for the first 50 ft., by 10-ft. intervals between 50 and 200 ft., and by 20-ft. intervals beyond 200 feet. Frequent tests also were made on the uniformity of the strata below the surface.

None of the quantitative data will be presented in this article but some brief conclusions will be drawn. Many of the tests yielded data that gave resistivity-electrode spacing curves of the type obtained from small scale work with two- and three-layer models. The curves made from data taken at four points in the foothills of Moscow Mountain in Idaho are especially distinct. These indicate a shallow, highly resistant medium underlain by a good conductor. Later in the fall the more exact mathematical calculations introduced by Tagg and Roman were applied to this data. The two methods gave comparable values for depths to the new stratum. The numerical values of the resistivity of the second stratum also were in close agreement.

It might be mentioned that the depths to the new stratum were less than the values that earlier had been assumed on the empirical basis of interpretation. The data were obtained before a working knowledge of the Tagg and Roman methods was available to the experimenter. Consequently, the field work was carried out without the extreme care necessary to obtain the exact value of the specific resistance of the first stratum required for use in the Tagg method of calculating. The electrode spacing was increased by 2-ft. intervals from 2 to 20 ft., by 5-ft. intervals from 20 to 50 ft., and by 10-ft. intervals beyond 50-feet. In two of the four tests mentioned the maximum distance between the electrodes was 120 feet. It was 150 and 200 ft. in the third and fourth tests. The average of the first values of the apparent resistivity gave a value that is believed to be reasonably accurate for the resistivity of the top stratum.

The underlying strata must be horizontal in order to permit the more mathematical calculations. The existence of such conditions is rapidly tested by determining the potential difference between a point midway between the potential stakes and each of the potential stakes in turn. Agreement of these values permits the conclusion that the underlying strata are horizontal.

The data recorded on the Soil Conservation Nursery near Pullman, Washington, throw interesting light on this last point. Tests were made in north-south and east-west directions. The conditions known to exist are shown in the drawing. (Fig. 7). The surface slopes to the south, then it drops abruptly, and a thick layer of basalt is exposed in the bluff. This basalt stratum is believed to slope to the north. The tests were made at a point approximately 600 ft. north of the edge of the bluff.

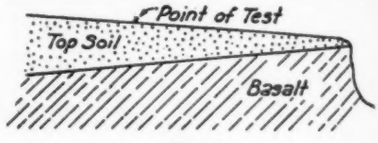

Fig. 7

The resistivity-electrode spacing curve in the north-south direction is a straight line for the first 200 ft. indicating that there probably is no disturbance due to the highly resistant basalt. The potential values from the center to each stake agree reasonably well. Beyond this spacing the value of the apparent resistivity increases, and most of the difference of potential was found to be to the south of the point at which the test was made. This is the side on which the depth to the basalt is least.

In the traverses in an east-west direction the electrode spacing was 170

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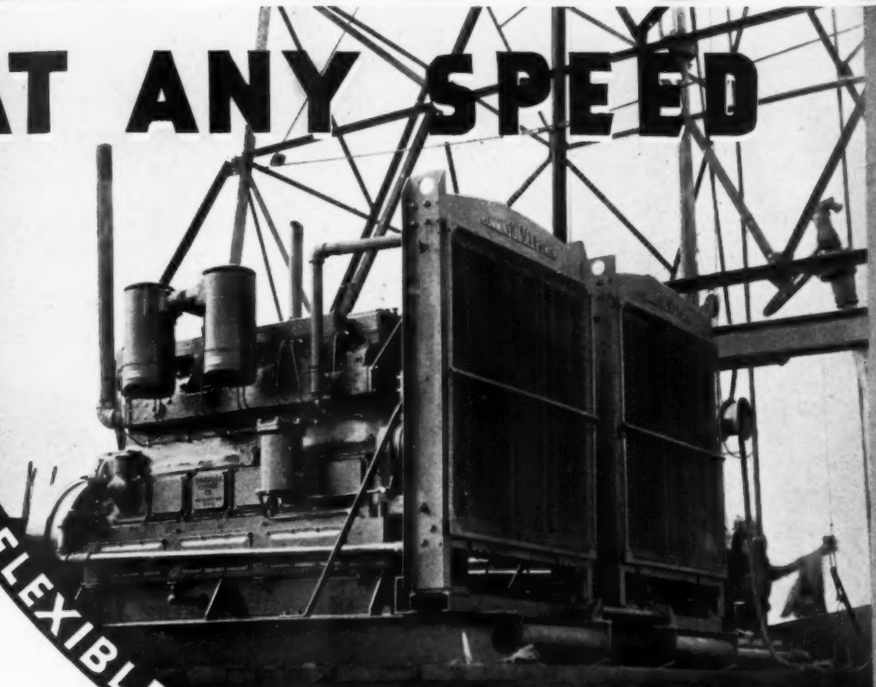

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feet. The values of the apparent specific resistance in the two directions vary by about 15 in 530 ohm-feet for a spacing of 120 feet. The variation is about the same for earlier readings. For the remaining values in the east-west direction the curve drops more distinctly below the one in the north-south direction.

The equipment as finally assembled and described in this article has cost the experimenter about $50, exclusive of potentiometer and wire. These articles can be bought for standard prices.

The use of the resistivity method is limited. The extent to which it can be used is mentioned here. The equipment described is compact, sturdy, and easily handled in the field. It has been tested in the field and laboratory and yields consistent data. This data must be used with the precaution mentioned.

Sincere thanks are to be given to the universities of Nebraska and Idaho for the use of laboratory space and the loan of equipment, especially during the preliminary experimental period. A grant of $25 from the American Association for the Advancement of Science, through the Nebraska Academy of Sciences, aided considerably in the final arrangement of apparatus. Dr. R. J. Watson, formerly of the University of Colorado, but now of the Carter Oil Company of Tulsa, Oklahoma, has kindly discussed many points of the problem of resistivity study and made many suggestions in the preparation of this article.

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Developments in Power Generation

A RECORD-BREAKING pressure of 2300 lb. per sq. in., nearly double that of the most modern high-pressure plants being installed, and a temperature of 940 deg. fahr., also higher than that in any plant now in service, are features of a turbine-generator under construction for the Indiana and Michigan Electric Company, subsidiary of the American Gas and Electric Company, for an extension of the Twin Branch Plant, Mishawaka, Indiana, says Guy Bartlett, of the General Electric Company, in writing of developments in the electrical industry during 1937. The 22,500-kw. unit will be cross-compounded with a new 45,000-kw., 385-lb.-pressure turbine-generator. Although somewhat higher pressures have been used in Europe, no unit so far has been operated at such a high temperature or on such a large scale, and in addition, forced circulation was required. Natural circulation will be used with the Twin Branch boiler.

The first hydrogen-cooled turbine-generator was placed in commercial operation during 1937. Sixteen hydrogen-cooled units representing more than a million kva., already have been installed or are under construction. One of these drives two generators.

To the 25,000-kw. topping turbine of the Dayton Power and Light Company went the distinction of being the first hydrogen-cooled turbine-generator in commercial service. The non-condensing turbine, at 1200 lb. gauge and 900 deg. fahr., drives a 3600-r.p.m. 31,250-kva. hydrogen-cooled generator. Hydrogen leakage at the shaft is prevented by oil-shaft sleeves; automatic equipment maintains the purity of the hydrogen within the generator at a pressure slightly above atmosphere. Fin-tube water coolers within the housing cool the hydrogen as it is circulated within the machine by the usual fans on the rotor.

Hydrogen cooling is to be used on the third 110,000-kw. vertical compound turbine-generator under construction for the Ford Motor Company. The set otherwise is like the second unit, already installed, with steam conditions of 1200 lb., 900 deg fahr., and one in. absolute back-pressure.

Hydrogen cooling was also provided for a 150,000-kw. triple tandem-compound turbine-generator in the State Line Station of the Chicago District Electric Generating Corporation. The turbine, the largest 1200-lb. unit ever built, is designed for use with steam at 825 deg. fahr. total temperature entering the high-pressure turbine — the steam being reheated to a temperature of 825 deg. fahr. before entering the intermediate section from which it exhausts directly into the double-flow low-pressure element. The generator, shipped as an air-cooled machine, has been provided with a hydrogen-tight housing, it having so happened that the construction of the generator made it readily adaptable to hydrogen cooling. The 150,000-kw., 0.9 power-factor, air-cooled turbine-generator set had a generator guaranteed for an output of 132,000 kw. at 0.85 power-factor, 155,300 kilovolt-amperes. Hydrogen cooling results in a guaranteed output of 150,000 kw. at 0.85 power-factor, 176,500 kilovolt-amperes, or a gain of 21,200 kilovolt-amperes. Also, with hydrogen, there is a reduction of losses at all loads of 878 kilowatts.

An example of a topping turbine installed in 1937 was the 25,000-kw., 3600-r.p.m. unit for the Monongahela West Penn Public Service Company at Rivesville, West Virginia. This unit has initial steam conditions of 1200 lb. and 925 deg. fahr. total temperature exhausting into low-pressure units.

A large topping turbine was also installed for the Appalachian Electric Power Company, Logan, West Virginia. The 40,000-kw. turbine is designed for 1250-lb., 925-deg. steam and exhausts at a pressure of 200 lb. gauge. The 3600-r.p.m. generator is hydrogen-cooled.

A 10,000-kw., 3600-r.p.m. topping unit was installed at Battle Creek, Michigan, by the Consumers Power Company. This turbine takes steam at 750 lb. and 850 deg. fahr. total temperature, and exhausts into the station mains at a pressure of 210 lb. gauge.

Still another topping unit installed was that of the Nebraska Power Company at Omaha, Nebraska. Here a 10,000-kw., 3600-r.p.m. topping unit uses 1200-lb., 900-deg. fahr. steam, exhausting into the station mains at 200 pounds.

Three units of the compact tandem-compound double-flow design with fabricated-steel exhaust hoods were installed during the year. The 20,000-kw. unit of the United Power Manufacturing Company at Davenport, Iowa, is designed for steam conditions of 825 lb., 825 deg. fahr. total temperature, and 1½-in. absolute back-pressure; the 25,000-kw. unit of the Public Service Company of Colorado is for 350 lb., 675 deg. fahr., and one in. absolute back-pressure; and the unit for the New York State Electric and Gas Company, Dresden, is for 650 lb., 825 deg. fahr., and one in. absolute back-pressure.

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Analysis of Maverick Springs, Wyoming, Crude Oil

A SAMPLE of oil from the Maverick Springs field of Wyoming has been analyzed recently at the Petroleum Experiment Station of the Bureau of Mines, Department of the Interior, at Laramie, Wyoming. The field is on the Shoshone Indian Reservation, Fremont County, Wyoming, in T. 6 N., R. 2 W. The first well in the field was drilled in 1918. During the next nine years 32 wells were drilled to the Embar limestone where production was obtained at depths from 1100 ft. to 1800 feet. The differences in well depths are due largely to well-head elevations, as positions of wells on structure account for only about 300 feet. It is estimated that these wells would produce approximately 6500 bbl. daily; however, no transportation facilities have been developed, consequently, little oil has been produced except that necessary for production tests.

Most of the crude oil produced upon completion of the wells was placed in storage tanks at the field. A sample of oil was obtained from one of these tanks in June, 1930, at a time when no fresh oil was available from the field. The storage tank was of bolted-steel construction, was painted red, and was not provided with vapor-relief equipment. The length of time the oil had been in storage was not known, but all of the wells in the field had been inactive for a considerable time. The analysis of this sample was made by the Bureau of Mines at Laramie, Wyoming, and was included in Bureau of Mines Technical Paper 538, A Survey of the High-Sulphur Crude Oils (Black Oils) Produced in Wyoming, by H. M. Thorne and Walter Murphy.

In September, 1937, a fresh sample was obtained by flowing the Continental Oil Company's well No. 7. This sample was analyzed at the Bureau of Mines Petroleum Experiment Station, Laramie, Wyoming, and the analysis included in this report.

A comparison of the two analyses show that the stored sample had lost by evaporation virtually all of the material distilling to 200 deg. cent. (392 deg. fahr.); otherwise, the samples are similar. The difference in percentage of kerosene distillate is due to the difference in the gravity of the distillates boiling between 225 deg. cent. and 250 deg. cent. (437 deg. fahr. and 482 deg. fahr.). By the Bureau of Mines method of interpreting Hempel analyses, a distillate having a gravity heavier than 40 deg. A.P.I. is considered a gas oil, although it may boil within the kerosene distillation range.

The following table shows the sulphur content of the two crude samples and their light distillates:

	Sulphur in crude, percent	Hempel Distillate up to 200 deg. cent. (392 deg. fahr.) Percent of crude	Hempel Distillate up to 200 deg. cent. (392 deg. fahr.) Sulphur, percent	Hempel Distillate 200-275 deg. cent. (392-527 deg. fahr.) Percent of crude	Hempel Distillate 200-275 deg. cent. (392-527 deg. fahr.) Sulphur, percent
Sample 37L-41 (fresh)	2.91	8.5	0.08	17.1	0.79
Sample 30-12 (stored)	3.19	1.4	.68	18.3	.80

Results of analyses of the two samples of crude oil by the Bureau of Mines Hempel method follow. Yields of products as shown in the "Approximate Summary" should not be interpreted as the yields that would be obtained in a commercial refinery.

STORAGE SAMPLE

(Collected 6/21/30)

Composite Sample, 1600-1700 ft., Ohio Oil Company — Maverick Springs, Embar Limestone — Wyoming, Fremont County, T. 6 N., R. 2 W.

GENERAL CHARACTERISTICS

Specific gravity, 0.938 — A.P.I. gravity, 19.4 deg.
Percent sulphur, 3.19 — Pour point, 5 deg. fahr.
Saybolt Universal viscosity at 100 deg. fahr., 550 sec. — Color, brownish black

DISTILLATION, BUREAU OF MINES HEMPEL METHOD

Dry Distillation — Barometer 583 mm. — First Drop: 171 deg. cent. (340 deg. fahr.)

Temperature deg. cent.	Percent cut	Sum percent	Sp. Gr. of cut	A.P.I. gravity of cut	Viscosity at 100 deg. fahr.	Cloud test deg. fahr.	Temperature deg. fahr.
Up to 50	.....	.....	.....	.....	.....	.....	Up to 122
50— 75	.....	.....	.....	.....	.....	.....	122—167
75—100	.....	.....	.....	.....	.....	.....	167—212
100—125	.....	.....	.....	.....	.....	.....	212—257
125—150	.....	.....	.....	.....	.....	.....	257—302
150—175	0.3	0.3	0.799	45.6	.....	.....	302—347
175—200	1.1	1.4	.....	.....	.....	.....	347—392
200—225	4.5	5.9	.815	42.1	.....	.....	392—437
225—250	5.5	11.4	.831	38.8	.....	.....	437—482
250—275	8.3	19.7	.847	35.6	.....	.....	482—527
Vacuum Distillation at 40 mm.							
Up to 200	1.3	1.3	0.872	30.8	45	10	Up to 392
200—225	8.6	9.9	.876	30.0	50	20	392—437
225—250	8.9	18.8	.891	27.3	61	40	437—482
250—275	7.6	26.4	.912	23.7	115	60	482—527
275—300	10.3	36.7	.923	21.8	200	75	527—572

Carbon residue of residuum, 16.9 percent. Carbon residue of crude, 8.0 percent.

APPROXIMATE SUMMARY

	Percent	Sp. Gr.	Deg. A.P.I.	Viscosity
Light gasoline	.....	.....	.....	.....
Total gasoline and naphtha	1.4	0.799	45.6	.....
Kerosene distillate	4.5	.815	42.1	.....
Gas oil	19.4	.850	35.0	.....
Nonviscous lubricating distillate	14.8	.876-.907	30.0-24.5	50-100
Medium lubricating distillate	11.2	.907-.923	24.5-21.8	100-200
Viscous lubricating distillate	5.1	.923-.929	21.8-20.8	Above 200
Residuum	43.4	1.012	8.3	.....
Distillation loss	0.2	.....	.....	.....

FRESH SAMPLE

(Collected 9/23/37)

Well No. 7, 1634-1649 ft., Continental Oil Co. — Maverick Springs Field, Embar Limestone — Wyoming, Fremont County, NE NW NW Sec. 15, T. 6N., R. 2W.

GENERAL CHARACTERISTICS

Specific gravity, 0.923 — A.P.I. gravity, 21.8 deg.
Percent sulphur, 2.91 — Pour point below 5 deg. fahr.
Saybolt Universal viscosity at 100 deg. fahr., 259 sec. — Color, black

DISTILLATION, BUREAU OF MINES HEMPEL METHOD

Dry Distillation — Barometer 586 mm. — First Drop: 117 deg. cent. (242 deg. fahr.)

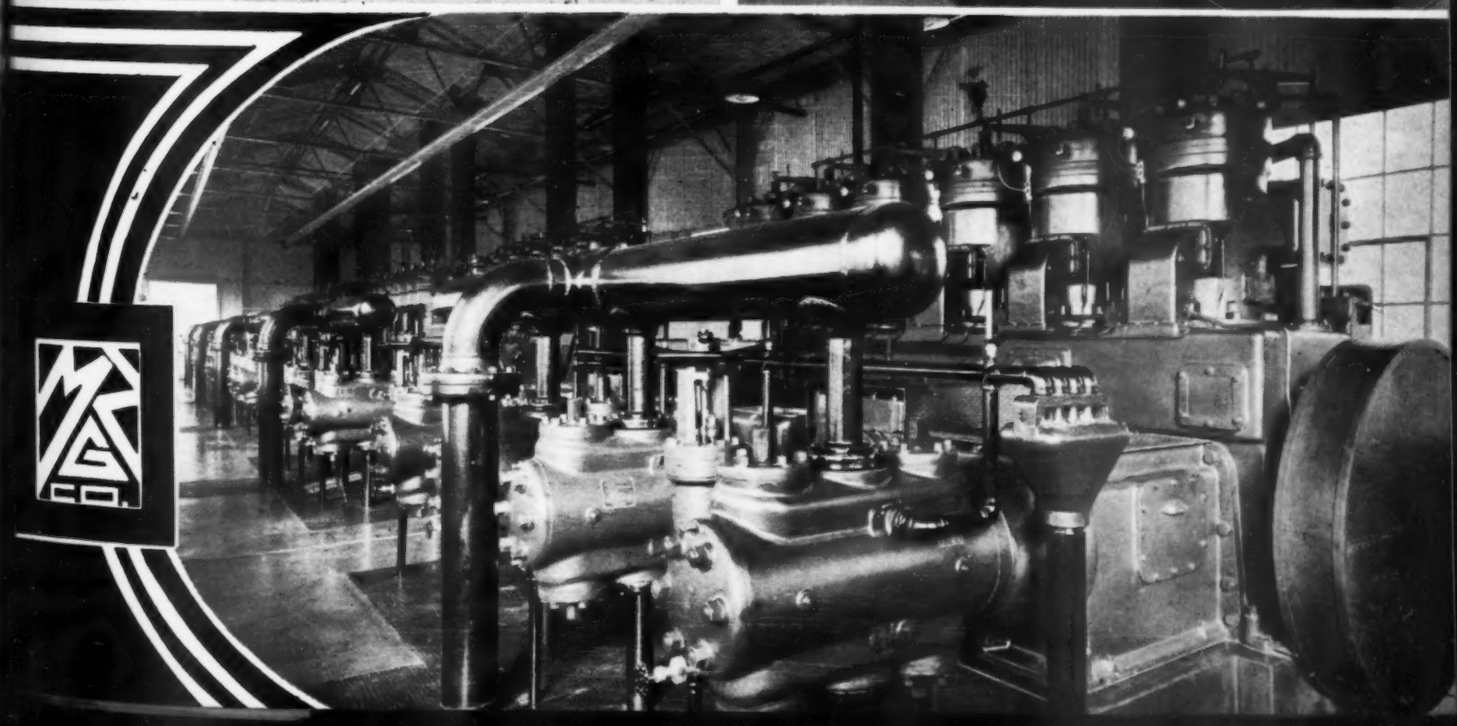
Temperature deg. cent.	Percent cut	Sum percent	Sp. Gr. of cut	A.P.I. gravity of cut	Viscosity at 100 deg. fahr.	Cloud test deg. fahr.	Temperature deg. fahr.
Up to 50	.....	.....	.....	.....	.....	.....	Up to 122
50— 75	.....	.....	.....	.....	.....	.....	122—167
75—100	.....	.....	.....	.....	.....	.....	167—212
100—125	0.5	0.5	0.731	62.1	.....	.....	212—257
125—150	2.0	2.5	.743	59.0	.....	.....	257—302
150—175	2.8	5.3	.764	53.7	.....	.....	302—347
175—200	3.2	8.5	.785	48.8	.....	.....	347—392
200—225	4.5	13.0	.807	43.8	.....	.....	392—437
225—250	5.2	18.2	.822	40.6	.....	.....	437—482
250—275	7.4	25.6	.840	37.0	.....	.....	482—527
Vacuum Distillation at 40 mm.							
Up to 200	1.3	1.3	0.865	32.1	44	10	Up to 392
200—225	6.5	7.8	.873	30.6	49	25	392—437
225—250	8.3	16.1	.889	27.7	62	35	437—482
250—275	7.3	23.4	.907	24.5	101	50	482—527
275—300	10.5	33.9	.920	22.3	180	70	527—572

Carbon residue of residuum, 15.5 percent. Carbon residue of crude, 6.8 percent.

APPROXIMATE SUMMARY

	Percent	Sp. Gr.	Deg. A.P.I.	Viscosity
Light gasoline	.....	.....	.....	.....
Total gasoline and naphtha	8.5	0.765	53.5	.....
Kerosene distillate	9.7	.815	42.1	.....
Gas oil	12.7	.852	34.6	.....
Nonviscous lubricating distillate	14.2	0.874-0.907	30.4-24.5	50-100
Medium lubricating distillate	11.5	.907-.923	24.5-21.8	100-200
Viscous lubricating distillate	2.9	.923-.928	21.8-21.0	Above 200
Residuum	40.3	1.011	8.4	.....
Distillation loss	0.2	.....	.....	.....

Wilmot Arkansas Compressor Station



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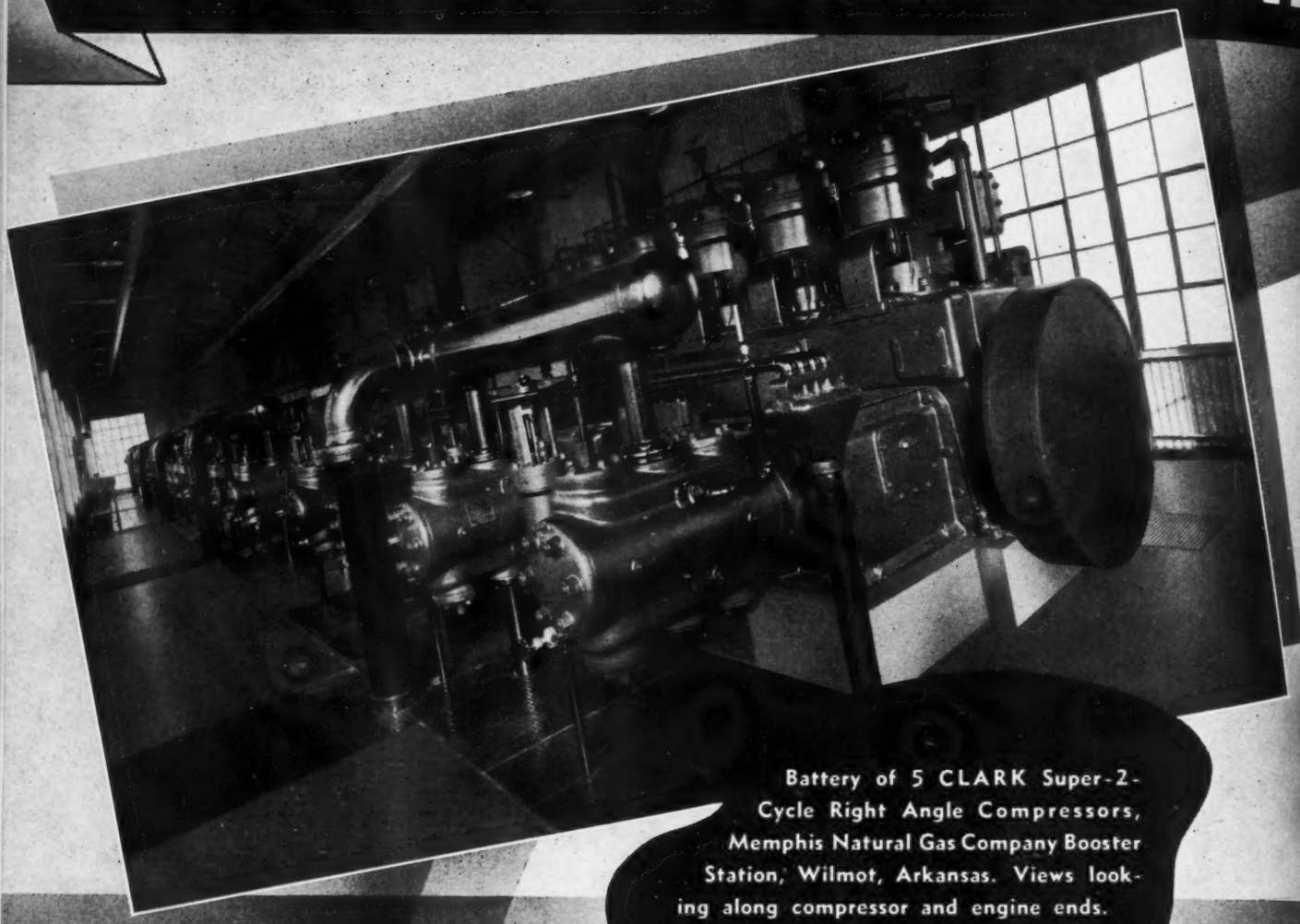
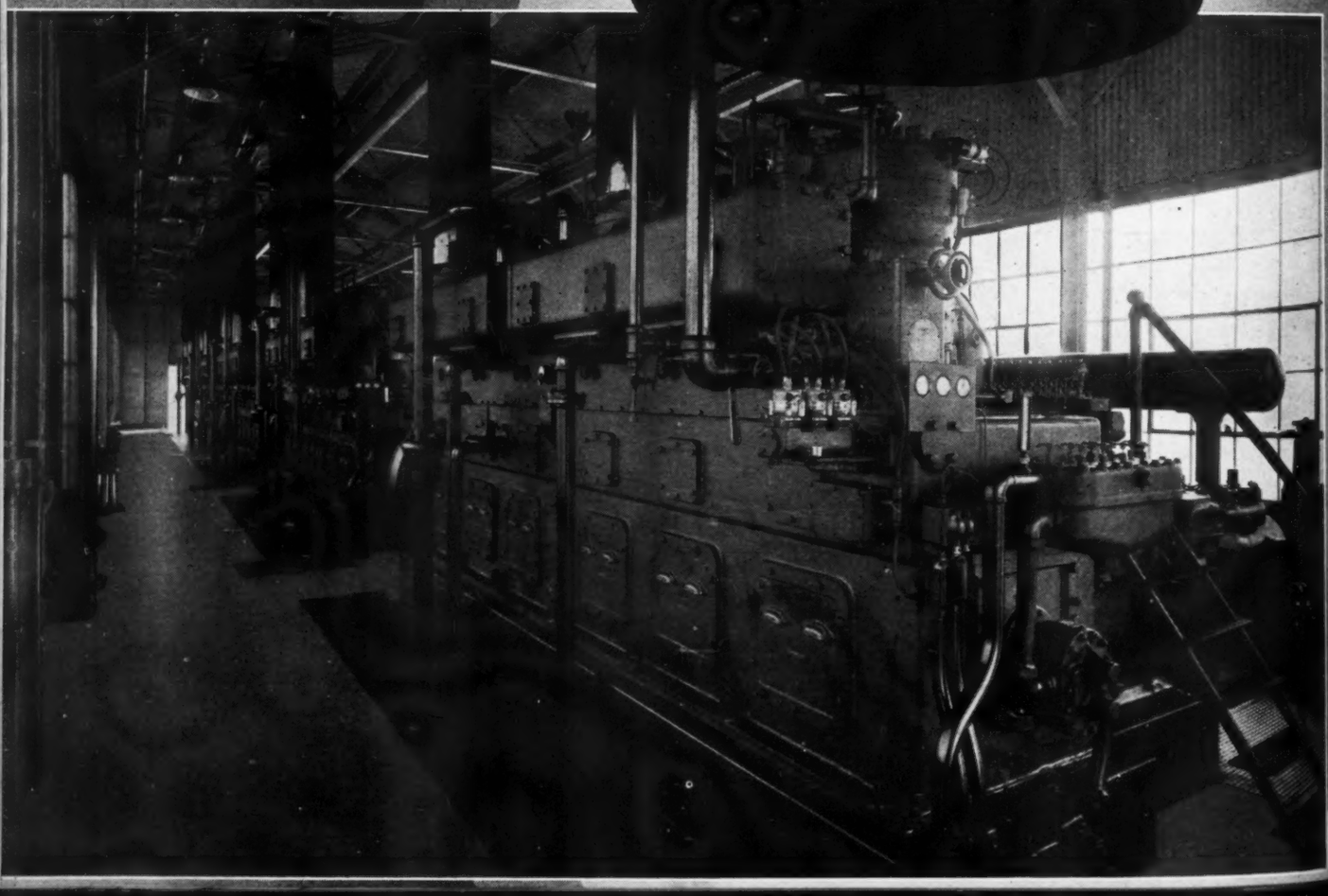
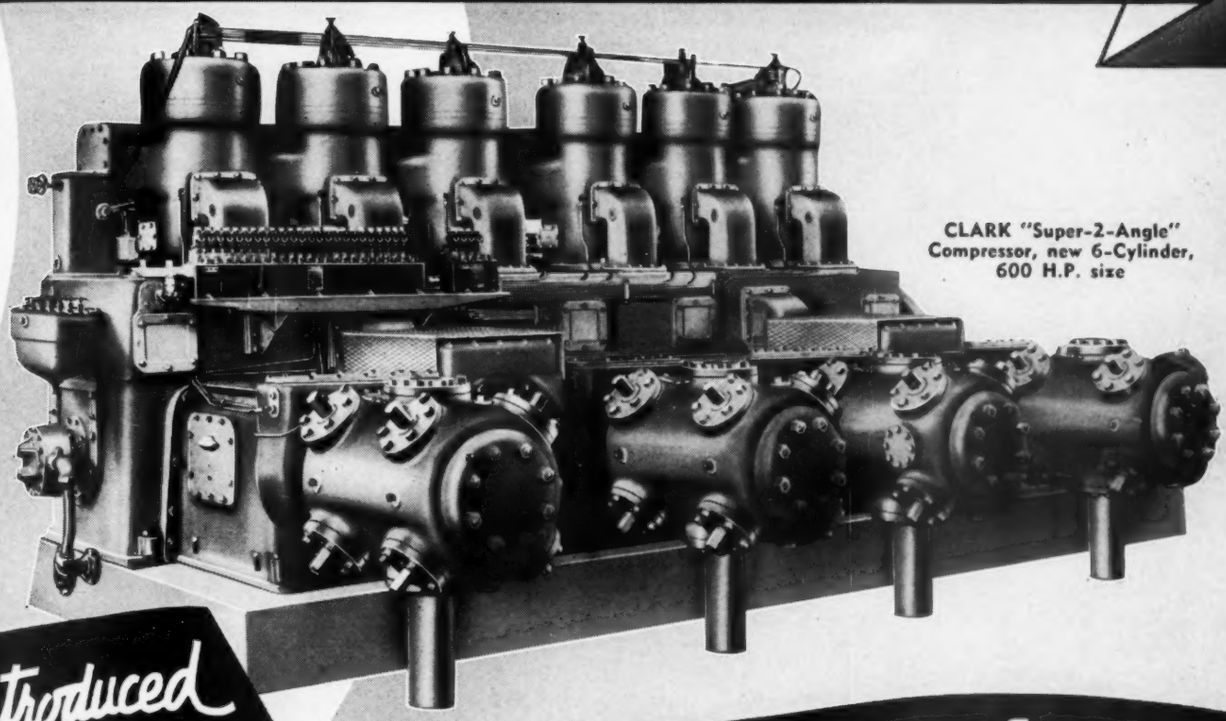


Battery of 5 CLARK Super-2-Cycle Right Angle Compressors, Memphis Natural Gas Company Booster Station, Wilmot, Arkansas. Views looking along compressor and engine ends.



ER-2-ANGLES



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1. SMALLER FLOOR SPACE AND BUILDINGS
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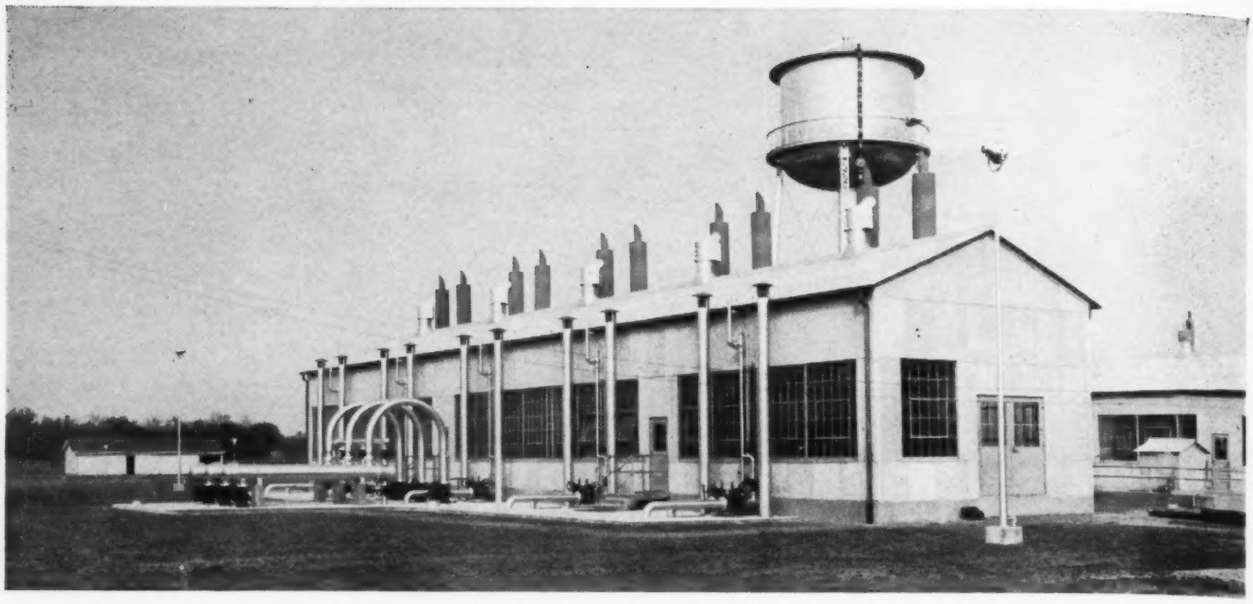


Main compressor building, in front of which can be seen the gas coolers and the gas manifold connections. Part of the auxiliary building at right

Memphis Natural Gas Company's Wilmot Compressor Station

Modern compressor units at this plant depart from conventional design and initiate a new trend in gas booster station practice

By H. C. WALLACE[1] and M. B. HIGMAN[2]

THE Wilmot, Arkansas, modern 3000-hp. compressor station of the Memphis Natural Gas Company recently completed and placed in service, marks a departure from conventional gas compressor station design. Its modern trend lies chiefly in the design of compressor units employed. Instead of the slow-speed horizontal-type single compressor machine, the compressor units are single-stage multi-cylinder horizontal compressors, direct-driven by vertical high-speed multi-cylinder gas engines. In keeping with the modern type of compressor units, the design and general layout of the station also incorporate many advanced engineering features.

[1]Chief Engineer, Commonwealth Gas System, Inc.
[2]Chief Engineer, Memphis Natural Gas Company.

Since this is the first booster station in large volume gas transmission service to be equipped with large compressor units of this type, and being a new development that may lead to further changes in gas booster station design, a description of the plant is timely.

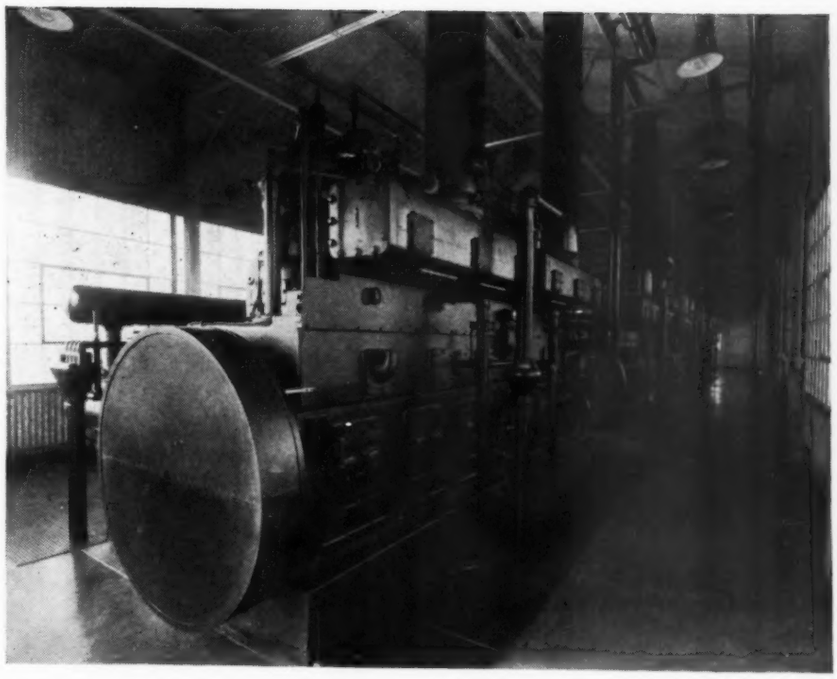
The Wilmot compressor station is about 57 miles north of Monroe, Louisiana, and about four miles east of the small town of Wilmot in the extreme southeast corner of the State of Arkansas.

Comprising the plant are the main compressor building, the building housing the auxiliaries, fuel meter house, elevated water tank, cooling tower, water well, lube-oil storage tank, gas coolers, hot-well, air-starting receivers, and two small buildings housing the sump pump and domestic water pumps, respectively. In addition to the buildings mentioned there are cottages for employees and a six-car garage on the north end of the station grounds.

THE MAIN COMPRESSORS

There are five main compressor units of 600 hp. each at a rated speed of 300 r.p.m. and consisting of a 6-cylinder, 2-cycle, 14-in. by 14-in. right-angle vertical engine, direct-connected to four 8-in. double-acting horizontal compressor cylinders. The compressor cylinders are designed to operate at a suction pressure of 150 to 250 lb. and a discharge pressure of 400 to 450 pounds. Clearance pockets and suction valve lifters are provided so

View in compressor building looking north along engine end of main compressor units



that, within the range of these suction and discharge pressures, the engine will not be overloaded and will operate at maximum efficiency. The capacity per unit can be varied from a maximum of 23,100,000 cu. ft. per day to a minimum of 11,000,000 cu. ft. per day. Each unit has two horizontal double-acting scavenging cylinders of 20-in. diameter.

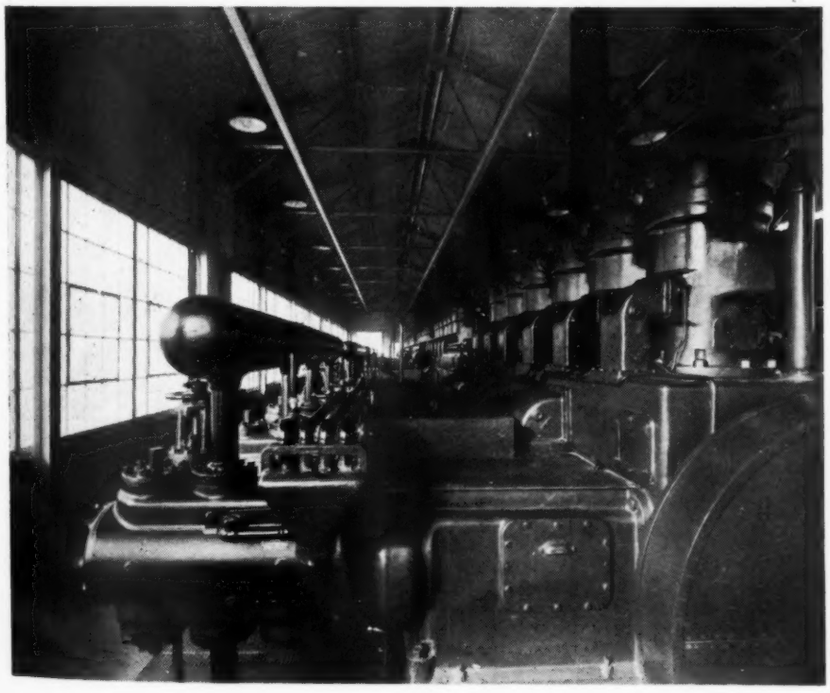
This right-angle gas-engine-driven compressor has incorporated in its design all the modern features of both the vertical gas engine and the horizontal compressor. The engine consists of a single row of vertical cylinders operating on the super-2-cycle principle. All four compressor cylinders and the two scavenging cylinders are driven directly from the engine crankshaft through a crosshead. The scavenging air is compressed to a pressure of approximately 3½ lb. and discharged into a common header in the engine, 35 percent excess scavenging air always being provided for complete and thorough scavenging.

Good balance is inherent in the design by virtue of the power cylinders being vertical and the compressor cylinders horizontal. It is a design that gives smooth operation with a minimum amount of foundation. This was an important item to consider at Wilmot, where the soil—so far as engine foundations are concerned—is very poor. The right-angle design also provides a compact unit that takes up little floor space, resulting in a saving in the cost of the building. Because of the high speed, a saving in transportation costs is effected through reduction in weight per horsepower. As this type of machine can be shipped in complete sections, savings in the cost of erection are also effected. These items combined make possible a considerable reduction in the initial cost per horsepower of main line booster stations.

All engine and compressor parts are easily accessible. Individual connecting rods to the compressor and engine give low bearing pressures and make easy repairs possible. Large handhole openings are provided in the crankcase and the covers are fitted with handholes, so that bearing inspection is very simple. Bearing replacement, particularly of main-bearings, is simplified, as the bearings are bronze-backed babbitt liners that can be rolled out.

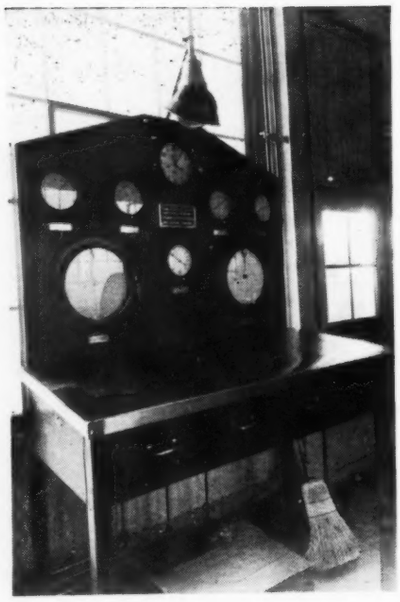
All engines in the main compressor building and also the auxiliary engine have overhead exhausts. These are insulated inside the buildings with Fluor-type jackets. In this design of jacket, an air space between the outside of the exhaust and the jacket forms an effective vent that carries off the heated air through the roof. The jackets have a 1½-in. thickness of insulation enclosed in metal, and are split for easy removal from the exhaust pipe. Heat of the exhaust pipe effects a natural draft of air out through the roof of the building.

The gauge board in the main compressor building has two indicating gauges for gas suction and discharge pressures; two recording thermometers for gas suction and discharge temperatures; and three indicating gauges for



View in compressor building looking north along compressor end of the five main compressor units

Gauge board in main compressor building



gas-fuel pressure, jacket-water pressure, and starting-air pressure.

Two chain-hoist trolley rails span the length of the main compressor building, one over the engines and one over the compressors. A trolley of 2-ton capacity is provided and is sufficient for repair work.

The air intakes to the compressor engines are equipped with simple strainers of ⅛-in. mesh hardware cloth supporting 40-mesh copper screen and are covered with a rainshed of 16-gauge galvanized metal.

The oil-coolers are in a trench in the floor on the engine side of the compressors.

Each engine flywheel is covered by a metal guard, and there is an almost complete absence of visible moving parts when the compressors are running.

SCAVENGING AND FUEL INJECTION

Air for scavenging is supplied by two double-acting horizontal compressors driven direct from the engine shaft. Each power cylinder receives a charge of approximately 35 percent excess air at a pressure of 3 to 3½ lb., thoroughly purging the cylinder of burned gases and leaving it with a full charge of fresh air, and so rendering the engine capable of carrying heavy temporary overloads.

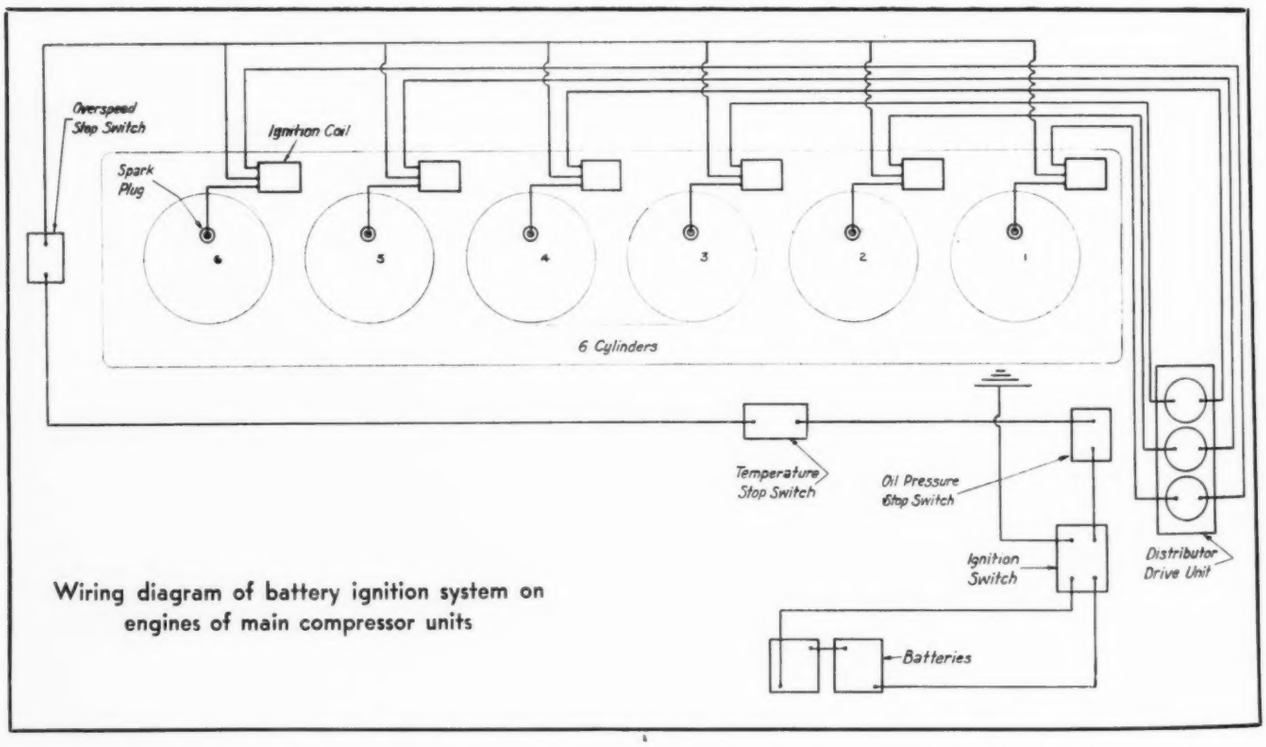
The super-2-cycle principle is used for fuel injection, and perhaps may be more readily understood by considering a complete operating cycle in one of the engine cylinders: After the spark plug ignites the charge, the power piston begins its downward movement and first uncovers the exhaust port, allowing the gases in the cylinder to drop to approximately atmospheric pressure before the scavenging, or intake, port begins to open. Just at the time the port begins to open, the pressure in the scavenging air passage is 3½ pounds. Scavenging air from this passage passes through the port, strikes a special deflector on the head of the piston and is driven upward, forcing the burned gases in the cylinder out through the exhaust port. As the power piston begins its upward or compression stroke, it first closes the intake port, and then the exhaust port. As the exhaust port closes, the fuel injection valve, which is a small poppet valve in the cylinder head, admits gas into the cylinder at a pressure of approximately 15 pounds. The fuel injection valve is so timed that none of the fuel gas charge is wasted, it being prevented from escaping by closure of the exhaust port. The result is a high thermal efficiency.

The small poppet valve is operated by a push rod. As the engine governor controls the pressure to the injection valve, the engine is not sensitive to variations in B.t.u. content of the gas and will operate economically over a wide range of fuel conditions.

LUBRICATION

All the main compressor units are equipped with full force-feed lubrication. A mechanical force-feed rotary drive lubricator and a gear-type pump, both driven from the layshaft, force the oil through the system. The gear-type pump also pumps oil for the oil-cooling system, which is incorporated in the lubricating system.

Oil is picked up in the crankcase by the gear-type pump and forced through



Wiring diagram of battery ignition system on engines of main compressor units

Water pumps in pit, auxiliary building

a double filter and an oil-cooler. It is then fed under pressure to a header on the crankcase from where it passes to the main bearings along the crankshaft. From the main bearings it flows through drilled holes in the crankshaft first to the crankpin bearings, thence through holes drilled in the connecting rod to the wrist pin bearings.

The mechanical force-feed rotary drive lubricator has three feeds to each power cylinder, one feed to each scavenging cylinder and one to each compressor cylinder. Oil is pumped to each power cylinder at three points to insure lubrication all around the bore. This lubricator also pumps oil to the compressor cylinder and metallic packing on the compressor piston rod.

OIL-COOLING

An advanced engineering feature of the compressor units is the oil-cooling system. All the engine pistons are oil-cooled, the same oil being used for cooling and lubrication.

Leaving the wrist pin bearing, the lubricating oil passes to a space underneath the crown of the piston. Moving through this space at high velocity, the oil removes much of the heat from the piston and then is returned to the crankcase, where it is picked up by a gear-type pump and recirculated through the lubricating and oil-cooling system.

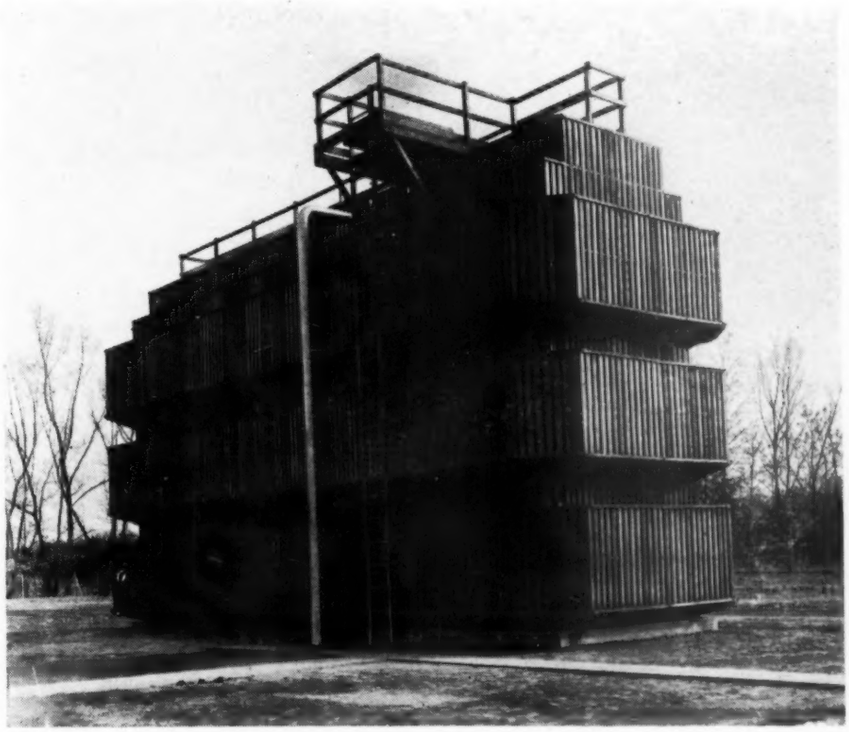
In addition to the elimination of the danger of contaminating the crankcase oil, there are other advantages to this method of oil-cooling. The lubricating oil is passed through coolers to maintain sufficient operating temperatures and improve lubrication. By cooling the oil the piston head temperature is reduced, the sticking of piston rings eliminated, and cylinder wall and piston ring wear minimized. The lubricating value of the oil is also increased by maintaining the oil at a more efficient viscosity for lubrication purposes. Bearing wear is reduced, compression improved by closer fit of the piston, the danger of cylinder-scoring decreased, and a substantial saving is thus effected by reduction of maintenance costs and shutdown time.

BATTERY IGNITION

A further example of improved design of the compressor engine auxiliaries is the battery ignition system, which operates from 12-volt batteries with low-tension distributors. All lines from distributors up to the ignition coils operate at only 12 volts; this minimizes line leakage and voltage drop. At the ignition coil the voltage is stepped up and a short wire connects the ignition coil with the spark plug. The failure of one coil does not shut down the entire engine.

There are dual leads from the batteries to each engine and a double-throw switch at the battery leads and at each machine.

The spark plugs on the engines have special mica insulation. The use of mica as an insulating material in the spark plug enables the plug to with-



Cooling tower of water-cooling system

stand mechanical shock and vibration without injury, and to be unaffected by rapid changes of temperature.

The batteries for the ignition system to the compressor engines are the wet cell type. They are housed in the auxiliary building and are arranged on a battery rack in three parallel banks of six cells each. The 18 Exide chloride cells are capable of supporting 16 amp. at 12 volts continuous rating. A Rectox battery charger, 115 volt a-c. to 16 volt d-c., completes the battery equipment, which includes an identical standby battery charger.

SAFETY DEVICES

Almost every contingency is provided for in safeguarding the engines. The electrical ignition system includes three auxiliary safety devices: (1) An oil-pressure stop that will shut down the engine at the minimum oil pressure for which the stop is set; (2) a temperature switch in the water-cooling system that will automatically shut down the engine when the water temperature gets too high; (3) An overspeed stop switch that will shut down the engine should the speed become excessive. These three valuable devices are operated by switches that break the ignition line and automatically prevent the spark plugs from firing, thus shutting down the engine and safeguarding it from injury.

Another important safety accessory is the Alnor exhaust pyrometer, which is mounted on the side of the engine in full view of the operator. This pyrometer indicates the exhaust temperature to the nearest degree at all times while the engine is in operation, and, by a turn of the selector switch the exhaust temperature of any cylinder can be observed. It is graduated from zero to 1200 deg. fahr., and is one of the most valuable gauges available to the operating engineer, as it indicates continuously the thermal efficiency of the engine under all operating conditions.

WATER-COOLING

A water well, 630 ft. deep, drilled about 50 ft. west of the cooling tower, provides the water supply for the station. Water is raised to the surface by gas-lift, and stored in a 30,000-gal. elevated steel water tank.

Of the five water pumps in the water-cooling system, two take suction from the hot-well and pump over the top of the cooling tower; two more take suction from the base of the cooling tower and pump through the gas coolers and engine jackets; the remaining pump is a spare, and can draw from either the hot-well or the base of the cooling tower and pump either over the top of the cooling tower or through the gas coolers and engine jackets.

The elevated water tank floats on the discharge of the water pumps that pump water through the gas coolers and engine jackets.

Raw water from the well discharges into a 6-in. line that goes to the hot-well. From the hot-well the water is pumped over the top of the cooling tower, then drawn from the cooling-tower basin and pumped through the gas coolers and engine jackets. It then returns to the hot-well, from where it is recirculated over the cooling tower.

In passing through the gas coolers the water temperature is slightly increased and this rise in temperature increases the efficiency of jacket-water cooling at the engines.

The cooling tower, a Fluor Aerator type, has a cooling capacity of 975 g.p.m. from 98 deg. to 70 deg. fahr. based on 45 deg. fahr. wet bulb and three miles per hour wind velocity.

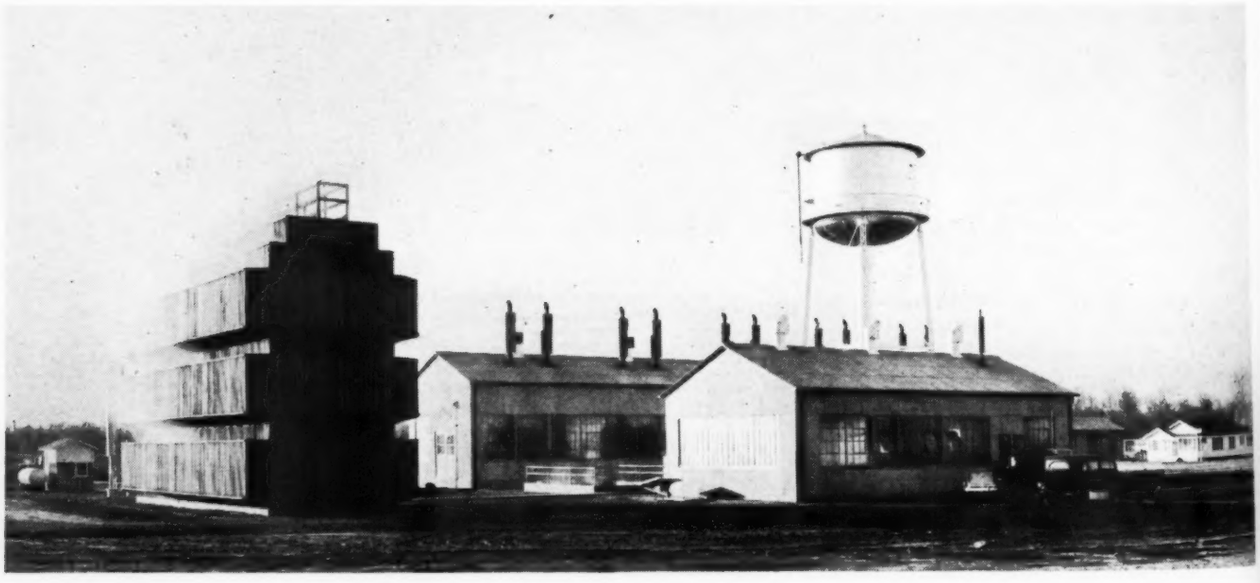
The water-cooling system is designed for semi-winter operation and is sufficient for cooling needs even through normal summer operating conditions.

In the event of an interruption in power service there is a supply of water available in the elevated tank sufficient, at the full rate of water circulation, for 35 minutes, or by allowing the water temperature to rise slightly, for 45 minutes. This allows ample time for placing the auxiliary generating unit—which can be used to supply electric power in an emergency—in service until purchased power service is restored.

GAS-COOLING

Coolers of the enclosed type are used for gas-cooling. Three coolers are provided on the gas discharge headers from the compressors, each designed for a maximum working pressure of 450 lb. per sq. in. in the shell and 100 lb. per sq. in. in the tubes. Their capacity is sufficient to cool 88 million cu. ft. (standard conditions) of compressed

View looking northwest showing cooling tower, main compressor building, and auxiliary building



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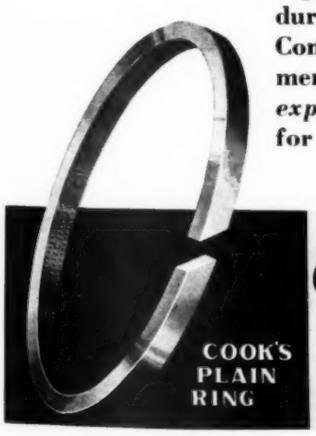

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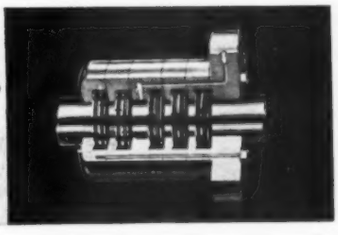


gas to 90 deg. fahr. under winter operating conditions, compressing natural gas from 225 lb. to 450 lb. per sq. in. pressure.

The coolers are equipped with thermometers on the inlet and outlet. Readings taken during initial runs of the plant showed that the maximum temperature of the gas from the coolers did not exceed 90 deg. fahr. when the temperature of the gas discharged from the compressors was 120-130 deg. fahrenheit.

GAS MANIFOLDS

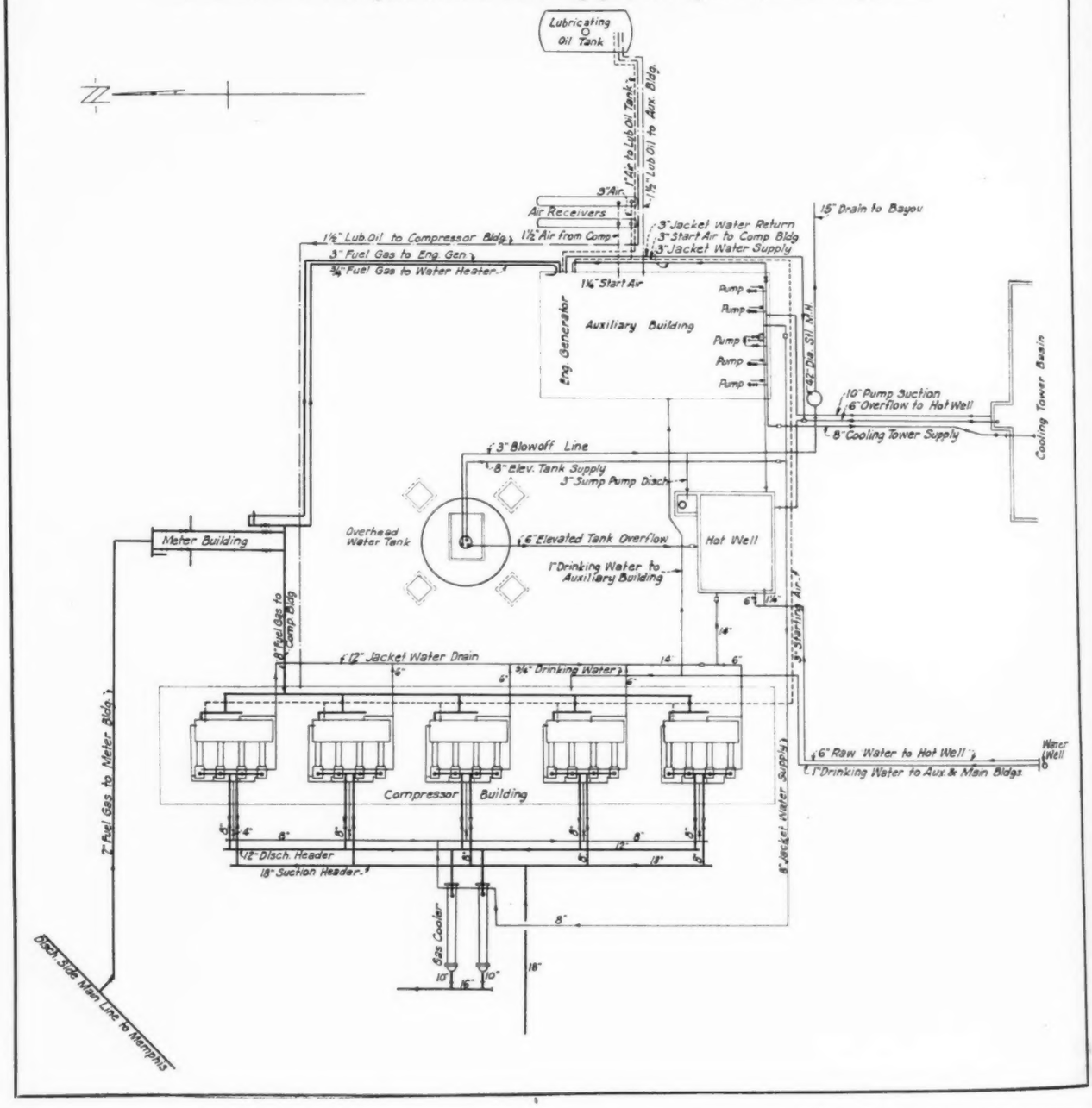
Gas is taken into the plant from the trunk line through an 18-in. suction line, thence through an 18-in. suction header in the ground outside the compressor building. From this header the gas is delivered through five 8-in. suction lines to each of the five 12-in. suction headers on the compressors, whence it is delivered to the compressor cylinders through 4-in. intake lines.

From the compressor cylinder the gas is discharged through 4-in. outlets into a 12-in. discharge header below the floor in a floor-plate-covered trench inside the building, thence through an 8-in. discharge line to another 12-in. discharge header outside the building, and from there through three 10-in. risers to the three gas coolers. From the coolers the gas is discharged through a 10-in. line into the 16-in. station discharge line which discharges into the trunk line.

Each of the five 8-in. discharge lines between the 12-in. compressor discharge headers inside the building and the 12-in. discharge header outside the building has a 3-in. by-pass on which is mounted on the discharge side a 3-in. riser to a 3-in. relief valve, set to relieve at 500-lb. pressure; also there is a 1-in. vent valve on the by-pass line.

(Continued on Page 105)

Flow sheet of the compressor station, showing gas, cooling-water, and fuel gas lines



Generator unit in the auxiliary building

(Continued from Page 102)

AUXILIARIES

In the auxiliary building are housed the electric power generating unit, ignition battery and chargers, switchgear in modern switchgear cubicles, two air-starting compressors, and five electric-motor-driven centrifugal water pumps, as well as the office of the chief engineer and a wash room with shower bath for the operators.

The electric generator unit consists of a 75-kw. 113-amp. 480-volt generator, driven by a vertical multi-cylinder, 4-cycle gas engine, which is of sufficient capacity to carry the full lighting and power load of the plant.

The battery ignition equipment for the main compressors consists of 18 wet cells in racks, and two battery-charging units.

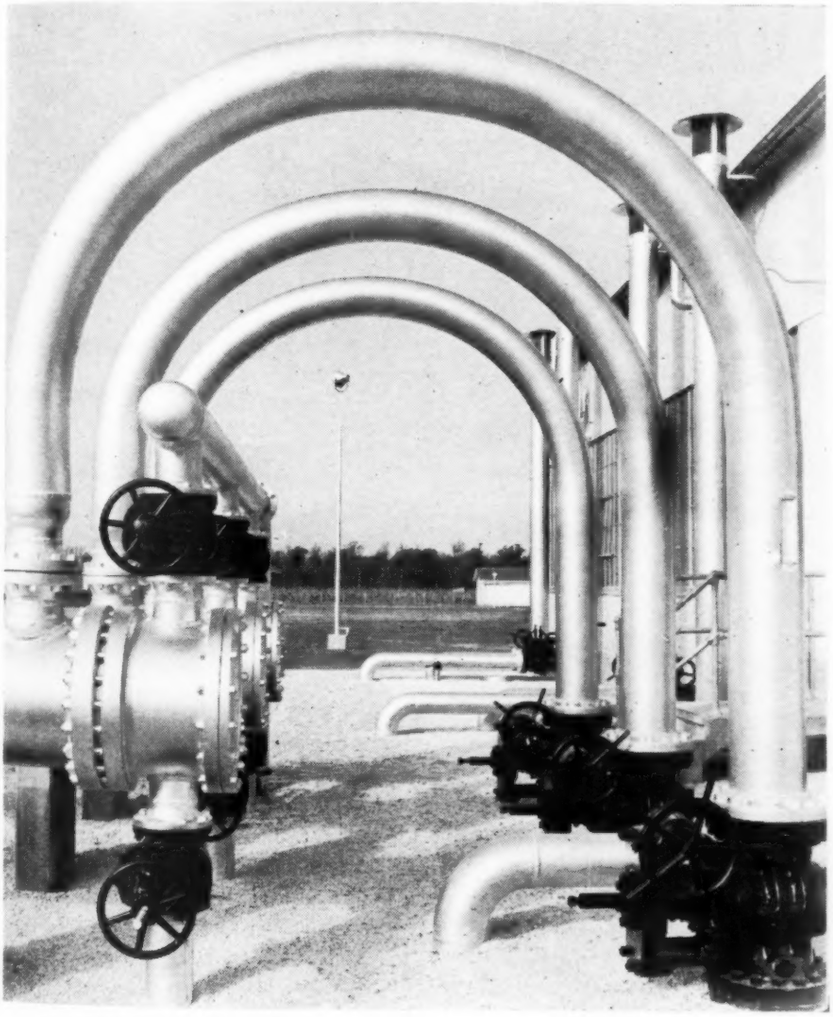
The starting-air compressors are the V-type. One is direct-driven by an induction motor with automatic pressure-actuated start-stop switch, and the other is driven by a gas engine through a 4-string V-belt drive.

All the water pumps are in a pit in the south end of the building. Each is an electric-motor-driven centrifugal unit with a capacity of 490 g.p.m. at a rated speed of 1750 revolutions per minute. All the pumps are connected by a 12-in. suction and a 10-in. discharge manifold.

The chief engineer's office is provided with a panel board equipped with indicating gauges that show the pressure of the water delivered to the cooling tower, pressure of the jacket water to the gas-coolers and engines, and recording gauges that record the gas suction pressure and gas discharge pressure. The office and wash room, the latter equipped with four steel lockers and shower, are constructed of hollow metal type partitions and doors.

There is one two-panel, totally-enclosed type switchgear cubicle, one panel consisting of one triple-pole double-throw oil-immersed circuit breaker for controlling auxiliary generator and local power company service and with the necessary instruments and voltage regulator, the other panel

(Continued on Page 108)



Discharge manifold connections to gas coolers

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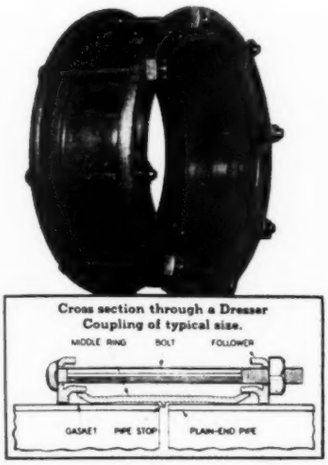
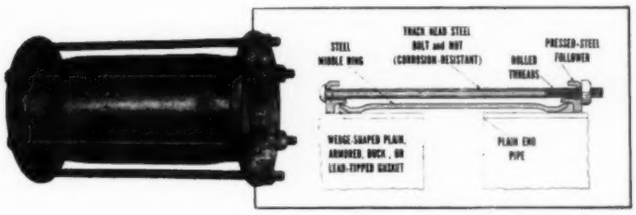


LEFT—Dresser Steel Coupling, Style 38. Longitudinal section below shows how it joins plain-end pipe in a flexible, yet permanently tight connection. Sizes available: ⅜" I. D. up.

BELOW—Dresser Long Sleeve (Long Coupling). Same as Style 38 Coupling, except has longer body to span variations in space between pipe ends. Sizes available: ½" I. D. up.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TAGES!

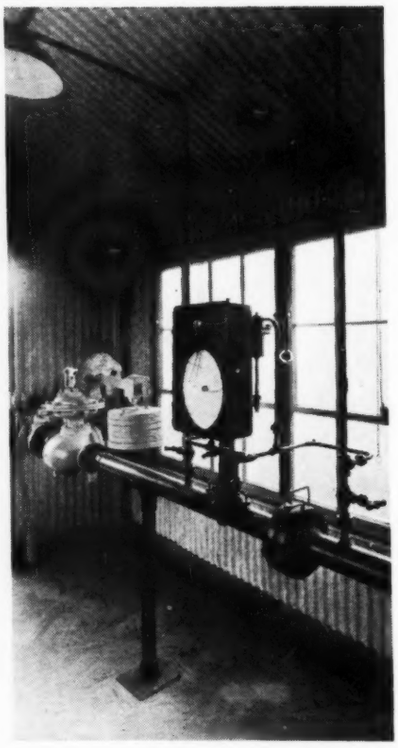
(Continued from Page 105)

containing ten automatic type 3-pole circuit breakers for all motor and power circuit control. In addition, there is one bank of lighting transformers and a 24-circuit panel for controlling all lights throughout the plant.

AIR-STARTING

Each of the two V-type air compressors has a capacity of 30 cu. ft. per min. at atmospheric intake pressure and 250-lb. discharge pressure. One is engine-driven and is equipped with battery and electric starter and also a crank for emergency starting by hand. The second compressor is driven by an electric motor equipped with a hands-off automatic control switch. The engine-driven unit is used only in an emergency and to bring up the pressure when a number of engines have been started simultaneously. The compressed air is stored in two receivers, 24 in. in diameter by 20 ft. long constructed to A.S.M.E. specifications for a working pressure of 250 pounds.

Air from the receivers is delivered to the main compressor building through a 3-in. line. Above each unit in the main compressor building there is an air header from which a 1¼-in. line is taken off to each engine. The engines have an air-starting valve on each cylinder, a valve in the cylinder head, and pilot valves on each control panel. An air pressure of 200 to 250 lb. is used for starting, though engines will start on 100-lb. pressure.



One of the two orifice meters and regulators on fuel gas line in meter house

LUBRICATING OIL STORAGE

An 8000-gal. horizontal tank is provided for lubricating oil storage and is designed for a maximum working pressure of 30 pounds. It is maintained at 10-lb. pressure by air. Two 1½-in. lines lead from the tank to the main compressor and auxiliary buildings. A valve and connection in the main compressor building for drawing off make-up lubricating oil as needed, are placed at a convenient height off the floor. A metal drip-pan with hardware mesh and a ¼-in. drain valve in the center is provided at this connection, the mesh helping to keep the oil cans free from drips.

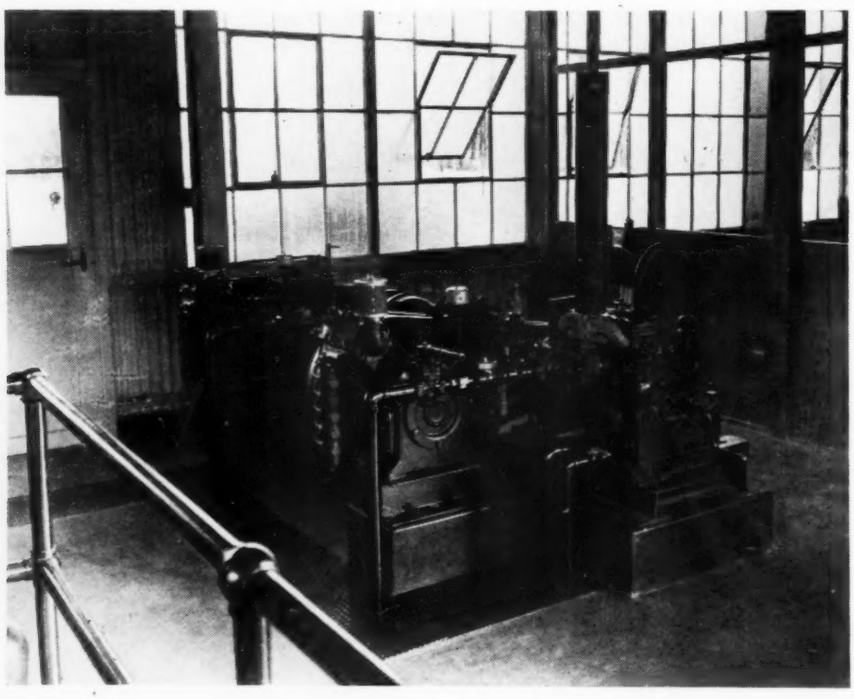
FUEL GAS SYSTEM

Fuel gas is taken from the suction header through a 2-in. fuel gas line to the meter house. Here the fuel gas line branches off into two meter runs, through each of which the gas is metered and the pressure reduced, first to 90 lb. and then from 90 lb. to 27 lb. per sq. inch. The gas then goes to a header in the compressor building where the pressure is again reduced at each engine to 17 lb. per sq. in., into a reservoir and thence through a 2-in. pipe and quick-acting shut-off valve to the engine mixing chambers.

In the meter house the two meter runs are each equipped with a recording pressure gauge; a 2-in. balanced valve pressure regulator (225 lb. to 90 lb.); an 8-in. expansion chamber, on the downstream side of which a riser with a 3-in. relief valve set to relieve at 125 lb. is installed; an orifice meter, on the upstream side of which the line is equipped with 3-in. straightening vanes; a 2-in. balanced valve pressure regulator (90 lb. to 25 lb.). From the 8-in. header to the main units are lines and regulating equipment for the fuel gas to the auxiliaries and gas-fired water heater.

From the meter house an 8-in. fuel gas line leads to the main compressor building and a 3-in. fuel gas line to the auxiliary building.

From an overhead fuel gas header in the main compressor building the gas goes to a pressure regulator (25 lb. to 17 lb.). Fuel gas is delivered to each engine through a 3-in. pipe and quick-acting shut-off valve to the engine mixing chambers.



The two V-type air compressors in auxiliary building

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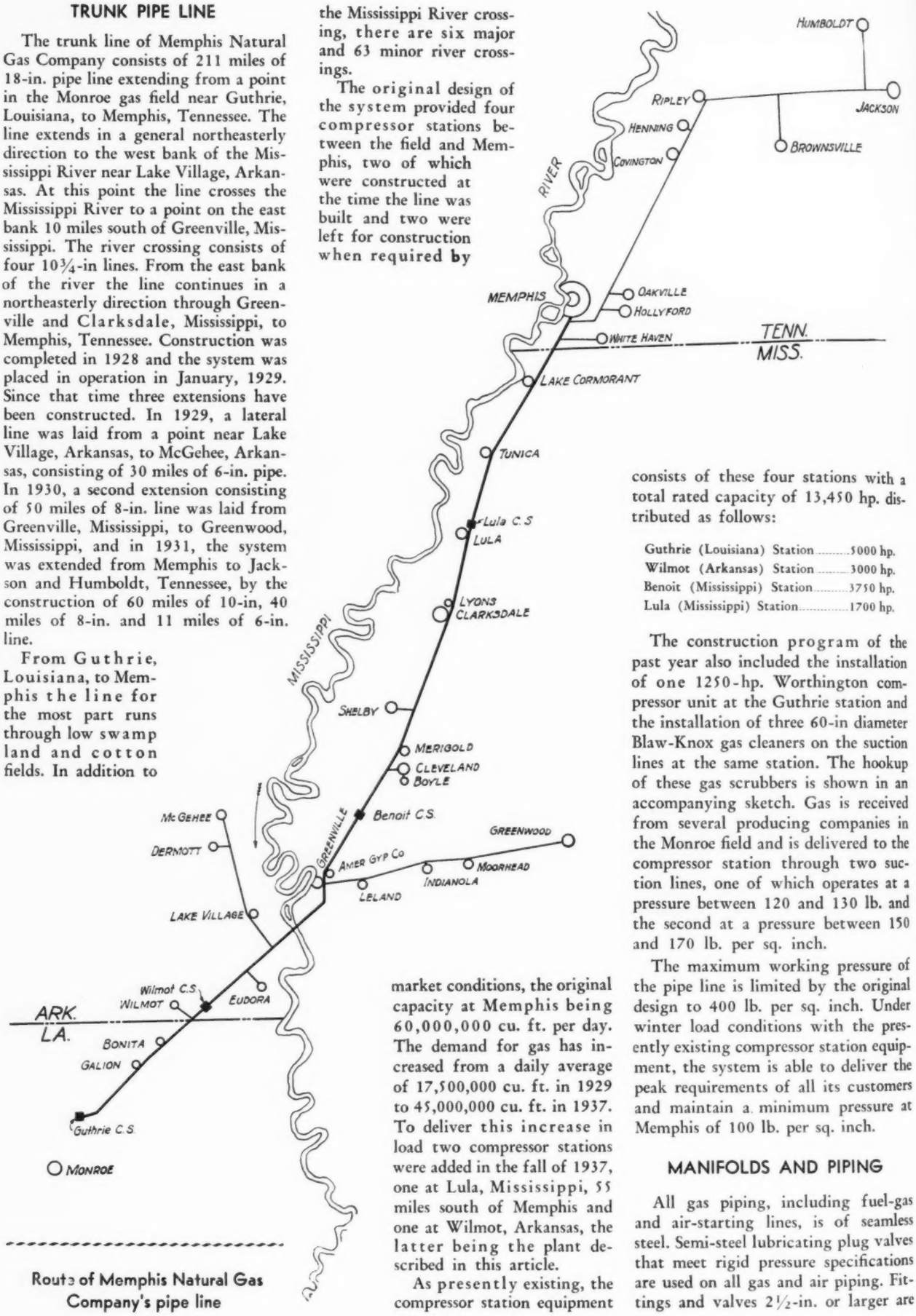
TRUNK PIPE LINE

The trunk line of Memphis Natural Gas Company consists of 211 miles of 18-in. pipe line extending from a point in the Monroe gas field near Guthrie, Louisiana, to Memphis, Tennessee. The line extends in a general northeasterly direction to the west bank of the Mississippi River near Lake Village, Arkansas. At this point the line crosses the Mississippi River to a point on the east bank 10 miles south of Greenville, Mississippi. The river crossing consists of four 10¾-in lines. From the east bank of the river the line continues in a northeasterly direction through Greenville and Clarksdale, Mississippi, to Memphis, Tennessee. Construction was completed in 1928 and the system was placed in operation in January, 1929. Since that time three extensions have been constructed. In 1929, a lateral line was laid from a point near Lake Village, Arkansas, to McGehee, Arkansas, consisting of 30 miles of 6-in. pipe. In 1930, a second extension consisting of 50 miles of 8-in. line was laid from Greenville, Mississippi, to Greenwood, Mississippi, and in 1931, the system was extended from Memphis to Jackson and Humboldt, Tennessee, by the construction of 60 miles of 10-in, 40 miles of 8-in. and 11 miles of 6-in. line.

From Guthrie, Louisiana, to Memphis the line for the most part runs through low swamp land and cotton fields. In addition to the Mississippi River crossing, there are six major and 63 minor river crossings.

The original design of the system provided four compressor stations between the field and Memphis, two of which were constructed at the time the line was built and two were left for construction when required by market conditions, the original capacity at Memphis being 60,000,000 cu. ft. per day. The demand for gas has increased from a daily average of 17,500,000 cu. ft. in 1929 to 45,000,000 cu. ft. in 1937. To deliver this increase in load two compressor stations were added in the fall of 1937, one at Lula, Mississippi, 55 miles south of Memphis and one at Wilmot, Arkansas, the latter being the plant described in this article.



Route of Memphis Natural Gas Company's pipe line

As presently existing, the compressor station equipment consists of these four stations with a total rated capacity of 13,450 hp. distributed as follows:

Guthrie (Louisiana) Station	5000 hp.
Wilmot (Arkansas) Station	3000 hp.
Benoit (Mississippi) Station	3750 hp.
Lula (Mississippi) Station	1700 hp.

The construction program of the past year also included the installation of one 1250-hp. Worthington compressor unit at the Guthrie station and the installation of three 60-in diameter Blaw-Knox gas cleaners on the suction lines at the same station. The hookup of these gas scrubbers is shown in an accompanying sketch. Gas is received from several producing companies in the Monroe field and is delivered to the compressor station through two suction lines, one of which operates at a pressure between 120 and 130 lb. and the second at a pressure between 150 and 170 lb. per sq. inch.

The maximum working pressure of the pipe line is limited by the original design to 400 lb. per sq. inch. Under winter load conditions with the presently existing compressor station equipment, the system is able to deliver the peak requirements of all its customers and maintain a minimum pressure at Memphis of 100 lb. per sq. inch.

MANIFOLDS AND PIPING

All gas piping, including fuel-gas and air-starting lines, is of seamless steel. Semi-steel lubricating plug valves that meet rigid pressure specifications are used on all gas and air piping. Fittings and valves 2½-in. or larger are

flanged, and all valves and fittings 2-in. and smaller are the screwed type. Forged-steel slip-on type welded flanges of the proper series for the working pressure, and fabricated seamless steel bends are used on all gas piping and manifolds. Electric welding was used throughout on all gas piping and manifolds; and all welded joints have reinforcing strips.

Electric welds on exposed piping were given a primer and then two coats of aluminum paint. All underground piping was given a primer of Bitumastic and an application of Bitumastic hot enamel.

Yard piping, including drains and all service piping, is standard lap-weld pipe and is equipped with long-sleeve couplings at proper intervals to take up expansion and contraction and to guard against injury from earth movement.

CONSTRUCTION

All buildings are of steel frame construction with corrugated asbestos walls and roof. Steel sash, pressed steel doors, and copper gutters and downspouts are used throughout. Structural steel, sash and doors were shop-primed and after erection received two coats of aluminum paint.

The windows are practically continuous around the main compressor and auxiliary buildings. Five 24-in. rotary ventilators, one over the center of each engine, are installed in the roof of the main compressor building. These, together with the exhaust jacket vents, ensure good ventilation and thorough circulation of air inside the main building.

All electrical conduit and fixtures in the main compressor building and the meter house are vapor-proof. All wiring is in galvanized conduit with plug outlets provided at four points in the main building, four points in the auxiliary building, and one point in the meter building.

Under the main building 162 piles 20 ft. long were driven to a bearing pressure of 20,000 lb. and set on 5-ft. by 4-ft. 6-in. centers. The engine foundations and the building are set on a concrete mat, 26 ft. 6 in. by 128 ft. 6 in. by 15 in. thick, reinforced top and bottom. The total quantity of concrete in the concrete mat is 158 cu. yd. and in the engine foundations 138 cu. yd., making a total of 296 cu. yards. Piling was also used under the gas-cooler footings, under the water-tower footings, and under the auxiliary engine foundation. The soil bearing strength was sufficient for carrying the load for the rest of the equipment. All foundations have spread footings.

Floors are finished in dark slate-grey concrete, sandpapered, surfaced, and waxed. Engine bases are finished in black concrete, dressed and waxed. Plywood was used on all concrete form work and exposed surfaces were stone-smoothed.

All drainage except that from roof eaves goes to the sump. All pipe trenches and the hot-well are set above grade because of possible floods; also the drainage lines to sump are equipped with check valves to prevent water backing up during floods.

The design and specifications for the station were prepared by The Fluor Corporation, Ltd., under the supervision of H. R. Marsh and in collaboration with the engineering departments of Commonwealth Gas System, Inc., Memphis Natural Gas Company, and

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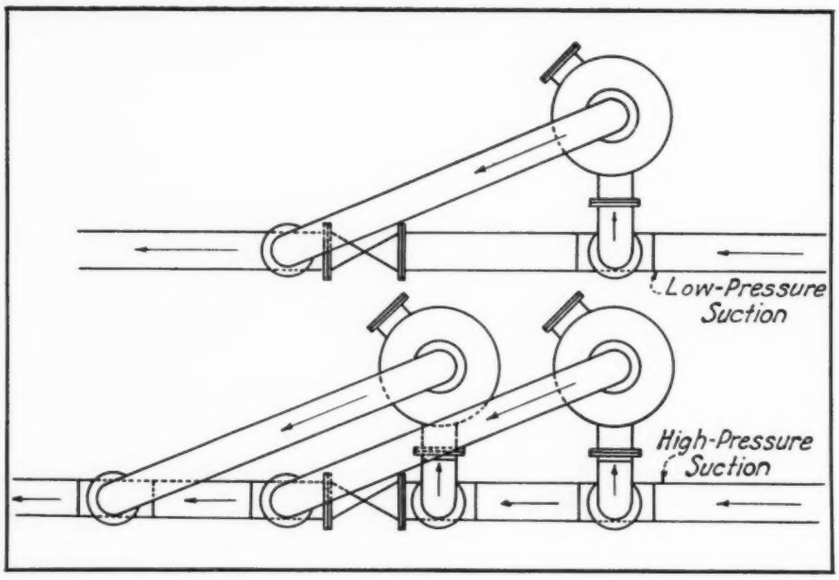

Above — Gas cleaners installed on main line

At left — The three gas cleaners are connected into the main suction of initial station on trunk line

Clark Bros. Company. The construction contract was awarded to The Fluor Corporation, Ltd., and construction began August 9 under the supervision of H. R. Marsh, with P. E. Jerde, construction engineer for The Flour Corporation, in direct charge of the job. The station was completed November 8, 1937, which in itself was a remarkable record in view of the difficulties that confronted the construction contractor.

Main compressor units before erection of building.

V. E. Ford, factory service man of Clark Bros. Company, supervised the construction of the main compressor units.

The station is now operating under the supervision of C. H. Bryan, compressor station superintendent for Memphis Natural Gas Company, with P. M. Benson in direct charge of the plant.

The Memphis Natural Gas Company, of which Birger L. Johnson is president, is an operating subsidiary of the Commonwealth Gas System, Inc., 50 Broadway, New York, N. Y., and maintains its principal office in the Sterick Building, Memphis, Tennessee.

Construction of gas manifold during erection of station.

List of Major Items of Plant Equipment, Including Name of Manufacturer

Gas Compressor Units—Clark Brothers Company.
Lubricators—McCord Radiator & Manufacturing Company.
Metallic Packing—C. Lee Cook Manufacturing Company.
Compressor Packing—Garlock Packing Company.
Exhaust Pyrometers—Illinois Testing Laboratories, Inc.
Battery Ignition System—United American Bosch Corporation.
Sparks Plugs (Main Engines)—The B. G. Corporation.
Oil Filters (Main Engines)—Motor Improvements, Inc.
Lubricating Oil Pumps (Gear-type)—Geo. D. Roper Corporation.
Fuel Gas Regulators (Compressor Engines)—A. W. Cash Company.
Lubricating Oil Coolers—Ross Heater & Manufacturing Company, Inc.
Elevated Water Tank—Chicago Bridge & Iron Company.
Water Pumps—Ingersoll-Rand Company.
Sump Pump—Goulds Pumps, Inc.
Air Filters—Columbian Steel Tank Company.
Cooling Tower—Fluor Corporation, Ltd.
Gas Coolers—The gas coolers are of Fluor design and were manufactured for the Fluor Corporation according to their specifications.—Struthers-Wells.
Manual Switch Gear Cubicles—Barr-Thorp Electric Company.
Safety Switch—Bull Dog Electric Products Company.
Electrical Equipment, including Motors and Switch-board—General Electric Company.
Lighting Generator and Exciter, Exide Chloride Cells, Battery Rack, and Rectox Battery Charger Unit—Westinghouse Electric & Manufacturing Company.
Electric Generator Engine—Clark Brothers Company.
Starting-Air Compressors—Gardner-Denver Company.
Pipe Bends and Welded Fittings—Crane Company.
Flanges—Taylor Forge and Pipe Works.
Yard Piping—National Tube Company.
Long-sleeve Couplings on Yard Piping — S. R. Dresser Manufacturing Company.
Lubricated Plug Valves—Walworth Company.
Relief Valves—Crosby Steam Gage & Valve Company.
Gas Regulators—Pittsburgh Equitable Meter Company.
Orifice Meters and Valves—American Meter Company.
Straightening Vanes and Orifice Meter Manifolds—Maintenance Engineering Corporation.
Recording Pressure Gauges—Foxboro Company.
Indicating Pressure Gauges—Consolidated Ashcroft Hancock Company.
Industrial Thermometers — Consolidated Ashcroft Hancock Company.
Structural Steel—Havens Structural Steel Company.
Partitions—Houserman Company.
Sash—Truscon Steel Company.
Corrugated Asbestos (Buildings)—Keasbey and Mattison Company.
Glass—Binswanger & Company.
Ventilators—Kornbrodt Kornice Company.
Conduit and Wiring—Crouse-Hinds Company.
Aluminum Paint—Feroleum Products, Inc.
Engine Paint—Lowe Brothers.
Yard Piping Paint—Wailes Dove Hermiston Corporation.
Gas Cleaners (Main Pipe Line)—Blaw-Knox Company.
Engineers and Constructors—Fluor Corporation, Ltd.

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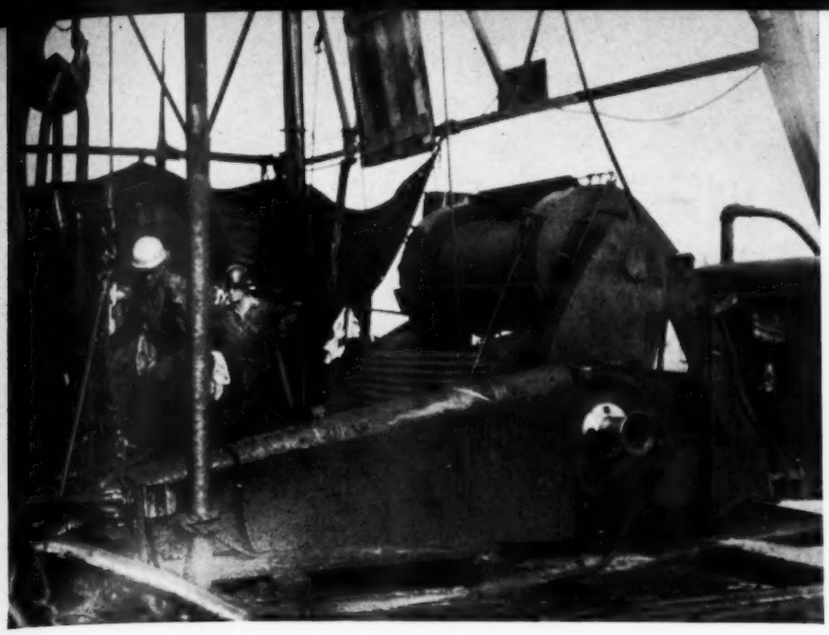


A two-drum portable hoist being used on a repair job in the Venice field, California

By

HENRY E. WINTER

District Engineer, Union Oil Company of California

Part I

Inexpensive Reconditioning of Oil Wells

The Union Oil Company of California has developed a highly effective procedure for repairing old wells in several of the California fields. In a paper entitled "Reconditioning Procedure with Portable Equipment" delivered at the Spring Meeting of the Pacific Coast District, A.P.I. Division of Production at Los Angeles, California, April 13, 1937, Mr Winters described in detail the equipment used and discussed many factors affecting the repair procedure treated in this article.

MANY factors must be considered before deciding to repair a well. The general subject of repair or reconditioning of oil wells includes a great variety of operations; but there are many wells the production of which can be increased in their present mechanical condition by the use of light or portable equipment that will keep the rigging-up expense at a minimum. Such operations are virtually of a "salvage" nature and do not involve redrilling or deepening a hole to lower zones. After due consideration of the economic factors presented by such wells, by study of all available past and present records, by the employment of a carefully-selected crew, and by application of proper equipment, some operators have obtained some very profitable results by stimulating production, shutting off water, and plugging back to upper zones.

In planning a repair job the economic factors first must be given careful consideration. These include the present ability of the well to produce above economic limits, the improvement that can be expected, the mechanical difficulties likely to be encountered, and the cost of the repairs. If a well's production is non-commercial, there is nothing to be lost by repairing it. If it is wet, the several factors to be considered include quantity of fluid, decrease in dehydration costs, tendency of water head to shut off flow of oil into the hole, possibilities of shutting off the oil with the water, and protection of oil zones from water. A future production problem that should be considered in some areas is the effect that the production of large volumes of water will have on water drive.

Detailed subsurface data are essential for successful repair work. In a great many wells the best results can be obtained by watching the details of the work as it progresses and correctly interpreting the results of each part of the operation. The records usually available before the job is started are the original well log, the production record, and the production crew reports. Frequently only meager information is available, especially if old wells are being investigated, and it is recommended that complete records of the production crew be turned over to the engineer to use in compiling the history of the well. Repair work involves a greater amount of detail work than does a new well, and over a period of time a record of fluid levels, bad casing, sand troubles, and other conditions that arise will, with the original drilling log, give the petroleum engineer valuable data with which to plan repair jobs. Electrical logging is aiding in many respects, and devices for locating formations through casing will help in deciding how to repair old wells that are difficult to correlate.

The success of the actual repair job depends on the crew doing the work. Repair work is dependent upon attention to details and careful measurements and the crew must realize the importance of their work. The best results have been obtained using a three-man crew consisting of a driller, derrickman, and helper. It also has been found advisable to use only three drillers and to shut down activity to get time off. All the men then have a

Looking upward in the derrick while running tubing after a repair job

This feeler is "home-made" and is run into the hole to determine if the casing is out to size and free of slivers or cement on the walls. It is also run to make sure that an inserted liner will go inside an old liner. The individual in the picture is Larry Lee of the Union Oil Company

continuous picture of the job and do not lose part of the sequence.

Equipment

The two-working-drum portable hoist has been found most desirable for repair work. This includes any type that can be moved from one location to another under its own power or by a truck. One drum handles the casing or tubing line and the other the sand line.

When a well is equipped with a steam or single-cylinder gas engine or electric motor driving a band wheel for pumping, a portable sand reel can be set between the samson post and the hole and can be driven from a split sprocket placed on the band-wheel shaft. If a rotary drawworks is available, either a semi-portable type or permanent equipment for tubing jobs, it can be used by installing the portable sand reel in front of the rotary drum to make a two-drum outfit.

The rotary equipment also is advantageous whenever necessity arises for drilling-out cement, and the steam pump provides the best means of circulation. A portable hoist equipped with a rotary table drive attachment, however, is satisfactory for this work, and cement may be drilled out using water as a drilling fluid, circulation being maintained by a portable gasoline lease pump.

Experience has proved that practically all types of repair work can be done without cable tools but there are jobs for which such equipment is desirable. By employing other methods, however, the expense of maintaining standard ends is eliminated. When it is absolutely necessary to use cable tools they generally can be rigged up temporarily with a portable steam boiler; and with a portable sand reel installed to save time in bailing there is less expense involved than in maintaining standard ends.

The condition of the hole should be thoroughly determined and the equipment for putting the well into condition for the repair work should be selected carefully. The top of the oil and of the water must be located; the sand should be cleaned out as well as possible; the condition of the casing must be determined definitely; and the deviation of the hole should be ascertained by the use of an inclination instrument.

Measurements are very important and definite rules should be given the drillers regarding measurements and the use and care of equipment run in the hole. Such rules formulated by the Union Oil Company several years ago are given to the drillers in typed form. They have been found extremely valuable and present in detail the procedure to follow in "stringing the derrick" and in making all measurements; in the kind of bailers to use and how to use them; the method for cleaning out and for dumping cement; the use of impression blocks; and the operation of a "feeler" devised by the company for determining whether the casing is out to size and whether it has slivers or cement on the walls.

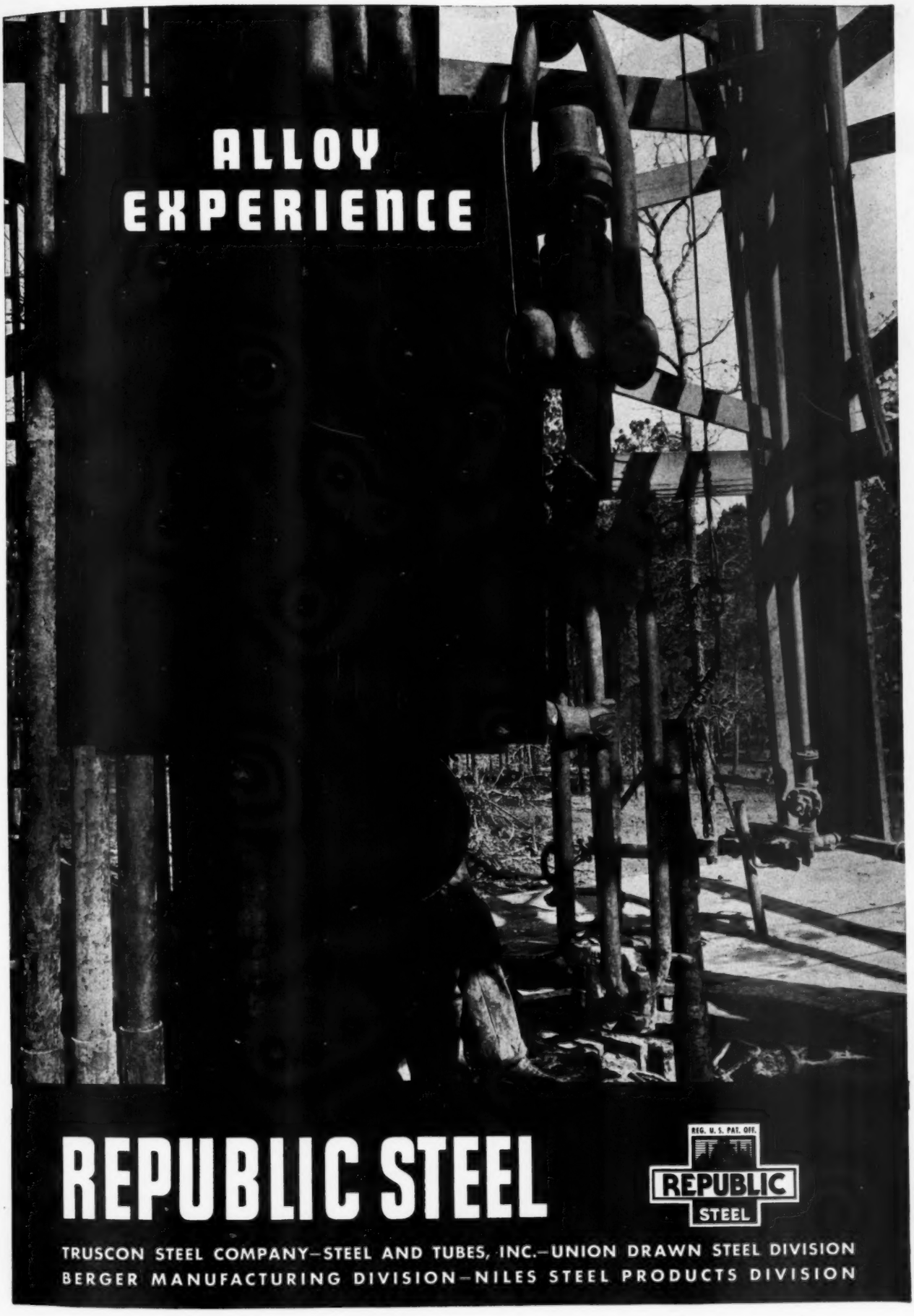
Stimulating Production

In many of the California fields the gross fluid produced by a well decreases until the well becomes non-commercial in its production or falls below the average of surrounding wells. The repair job is then one of stimulation of production and is planned to increase the amount of fluid in the well. It is the general assumption that in such a well the perforations are clogged; it is admitted that this assumption is logical and frequently it is correct.

It is the writer's theory, however, that as a well is produced the oil moving toward the hole carries with it a small amount of silt or colloidal material that tends to accumulate in the pores and clog the sand. This clogging action may be aggravated by the wax deposition of certain types of oils and may form a ring of impervious material around the well. Such action may take place several feet from the perforations so that no amount of perforation washing would do any good. If certain salt waters are being produced with the oil the condition may be further aggravated by chemical action or deposition of salts.

Just how this trouble may be over-

A dart and some of the shoes used with the bailer bottoms in repair jobs



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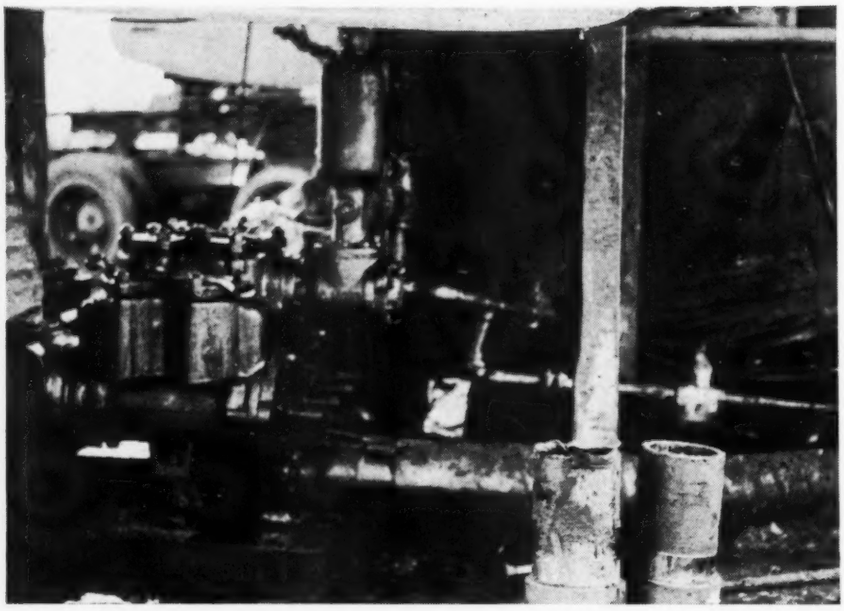

A portable pump used on repair jobs. This pump was originally electrically driven but has been converted into a gasoline-engine drive. Transmission of the power is through V-belt drive

come is not known as yet, although some wash-back action with the proper fluids or chemicals may open up the passages for the oil. In one field in particular the addition of a hydrostatic head of water in cementing bottom water seems to increase the production of the oil. Possibly the infiltration of water into the sand tends to dislodge these deposits. Just how far back in the formation this clogging takes place probably is governed by permeability and porosity.

Assuming that the perforations are clogged, however, several methods of cleaning are used. Swabbing, by means of a swab cup fastened to the jars and run up and down past the perforations, is the simplest and cheapest method. In cleaning a short, all-perforated liner the ball check can be left in the swab assembly; for washing perforations in an oil string, or solid casing extending to the surface, the ball check is removed. The best practice is to leave out the ball check and insert in the bottom of the swab assembly plugs with various sized openings. The openings can be varied to suit the hoisting power and condition of the sand line. The faster the swab is pulled the greater will be the agitation to force the fluid through and around the perforations to clear them. This method is used to advantage only if perforations are closely spaced or if it is thought that the fluid should pass from one hole to another down the outside of the liner or casing. Approximately the same agitation can be produced with drill-pipe protectors fastened to the bailer.

"Down-swabbing" is effected by putting an inverted swab cup on the bottom of drill pipe or tubing and lowering it rapidly past the perforations. A ball check or small bean plug is used to force the fluid through the perforations and around the cup and is especially necessary if the fluid level is low. This procedure is rather severe and is particularly drastic for old liners that are not suspended on liner hangers.

Two basic kinds of perforation cleaners are available on a rental basis. One operates by means of a suction that varies with the hydrostatic head of fluid in the well, and obviously is more effective with a nominally high fluid level. Raising the fluid level by the addition of fluid is not effective as the added head will tend to hold back the sand. This cleaner is run on either sand line or tubing.

The other type of perforation cleaner operates by means of a plunger or piston action that forces fluid outward through a number of perforations isolated by swab cups. It tends to open the perforations, and to complete the job the well is swabbed or bailed. It probably gives best results in wells of low normal fluid level. It is run on tubing or drill pipe.

Experience has shown that the best results are obtained by treating the perforations twice. The first swabbing or cleaning seems merely to loosen the foreign matter and the second, which should be more thorough, seems to be the more effective.

The use of chemicals still seems to be in an experimental stage although some beneficial results have been obtained in California wells. Up to the present time, however, chemicals have not been used as effectively in this state as they have in the Mid-Continent.

As a last resort for stimulating production, the pipe may be reperforated. This operation is referred to as a "last resort" because the perforated casing usually is old and corroded or is line-cut and the addition of more holes may cause its collapse.

Heaving Plugs

Heaving plugs are used to overcome sand trouble. Many old wells drilled with cable tools carried casing when drilled into the sand and thus have an open bottom in the casing. With the present practice of hanging liners on liner hangers, the liner is stopped a few feet off bottom; but during production clean-outs when a well is cleaned to bottom, a wrong measurement may result in knocking out the bottom of the liner with a bailer. As a repair measure for either defect, a bridge plug equipped with slips to prevent its movement up the hole can be set at the bottom of the string. Care should be taken to make sure that the bridge plug will go down the liner as its failure to do so will necessitate its being drilled up—and usually there is no drilling equipment on the job. The simplest method is to clean the hole carefully and dump a sack of cement on bottom or to fill the hole until the cement extends up into the liner approximately three feet.

Inserting Small Liners

If the liner is worn or wire-cut and the possible increase in production does not justify rigging up to insert a new liner or to redrill, a small liner can be set. A "feeler," however, should first be run to make sure the inserted liner will go down. The inside liner should have plenty of perforations and some strength can be sacrificed as it is supported on the outside by the old liner. The inserted liner should be brought up above the old liner and a new adapter set in the water string. When it is in place a few gun perforations will insure that some holes line up if sand packs between the liners.

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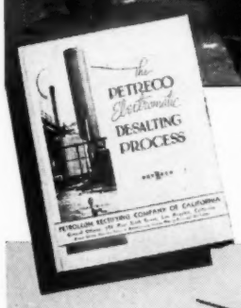

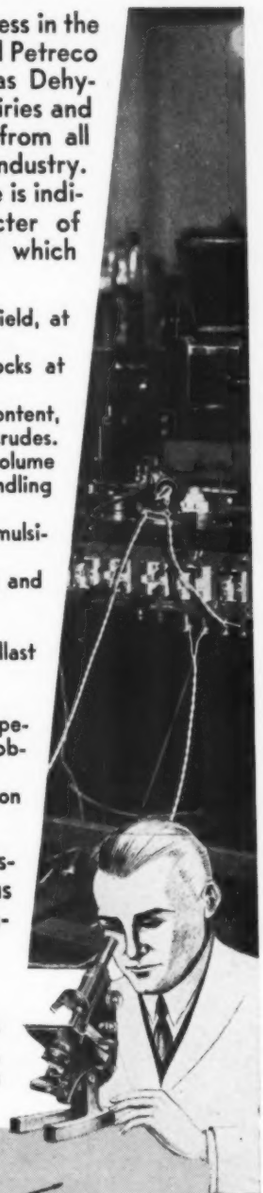

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Synthesis of Lubricating Oil by Polymerization of Gaseous Hydrocarbons

Factors affecting relative yields of olefinic and paraffinic compounds under diverse operating conditions

By RAFAEL FUSSTEIG

RESOURCES of gaseous olefin hydrocarbons derived from petroleum and coal are very large. These resources likely will increase considerably in the near future due to developments in the methods of cracking of natural gases, vapor-phase cracking of petroleum, and the intended development of the low-temperature carbonization industry.

The yield in Germany of olefins from carbonization at high temperatures is now estimated to be as great as 200,000 tons yearly, using only excess gas from coke ovens and gas transmitted through long pipe lines.

Taking into consideration the abovementioned developments of the coking and carbonization industries in the United States, together with developments in vapor-phase cracking of petroleum, which should also include cracking of primary tars, the problem of utilizing this large quantity of olefins will arise. It is clear that these quantities are too great for complete utilization in the alcohol, glycol, etc., industries.

Thus a condensation of olefins to light products and lubricating oils, the demand for which is very high, appears to be a very important technological problem, particularly inasmuch as the preparation of ethyl alcohol from ethylene is too expensive.

Investigations of the thermal polymerization of gaseous olefin hyrocarbons under atmospheric and elevated pressures to motor fuels of the gasoline-type of high anti-knock value have solved this problem. The fractionation of such a polymerization product gives a residue of no lubricating character, however. It is thus seen that the polymerization process is unable to transform gaseous olefin hydrocarbons into liquid compounds of high lubricating value. It is true that the exact chemical composition of lubricating oils could not yet be entirely determined, but it seems to be a fact that the proper viscosity and the formation of the lube film depends to a considerable extent upon the presence of hydrocarbons having closed rings of carbon atoms.

According to the experience of the writer, in the polymerization of gaseous olefin hydrocarbons it should be impossible to alter the direction of reaction, that is, under conditions in which gasoline-like hydrocarbons are formed, it would be impossible to produce, instead of hydrocarbons with open chains only, a portion of hydrocarbons having a ring structure of lubricating character.

On the other hand, it would be greatly desirable to be able to carry out a process in which a motor fuel having high anti-knock value and lubricating oils of high value are formed simultaneously. Consequently the writer has carried out some investigations to determine if this could be done.

Investigations led to positive results, but before going into the details, it will be well to review the literature on the synthetic preparation of lubricating oils, as well as that on the chemical composition of lubricating oils.

The preparation of synthetic liquid hydrocarbons is no modern discovery. It was known in the nineteenth century but at that time was only of purely scientific interest. Sabatier[1], the French investigator, mixed an organic gaseous substance with hydrogen of great purity, allowing this mixture to pass through a layer of a proper catalyst.

This experiment was performed under atmospheric pressure and high temperature, resulting in the formation of petroleum-like heavy hydrocarbons. Since the World War German investigators have been working intensively on methods of changing solid combustibles into liquid hydrocarbons. Bergius was the first to be able to carry out this process, but the method has encountered innumerable obstacles.

To determine a means of avoiding these difficulties many experiments have been conducted by Fischer and Tropsch, who found that for this purpose coal or coke should be first transformed into gas, that is, into the active carbon monoxide and hydrogen known as water gas. When this gas was subjected to the proper conditions, and a proper catalyst used, Fischer and Tropsch succeeded in the saturation of the carbon monoxide. Of course, in the second phase, the oxygen molecules were split and combined with hydrogen and the remaining $=CH_2$ molecules polymerized into hydrocarbons, this polymerization depending upon the conditions under which the process was performed. In other words, for the polymerization to be performed successfully hydrocarbons must be used that will form unstable gaseous unsaturated hydrocarbons, i. e., active $=CH_2$ molecules. Other investigators have used gaseous or liquid olefins in free state or combined with other hydrocarbons, these polymerizing in greater chains. The acceleration of this process can be attained by using different factors, such as ultra-violet light, electrical discharge, heat, pressure, and catalyst.

The action of these factors has been observed for a long time. Buttlerov[2] studied the formation of lubricating oils with the chemical aid of concentrated sulphuric acid, and obtained a polymerization product whose hydrocarbons possessed a lubricating quality; however, instead of sulphuric acid, other polymerization catalysts can be used, such as aluminum chloride, iron chloride, zinc chloride, as well as gaseous hydrofluoboric acid. In the early days of the development of the cracking processes, however, only polymerization with concentrated sulphuric acid was taken into consideration. Thus Guiselin[3] continued the studies of Buttleroff, and found that when cracking fractions rich in olefins were treated with concentrated sulphuric acid, heavy hydrocarbons containing a lubricating value were produced. Otto[4] experimented with the polymerization of olefins by means of hydrofluoboric acid, using a proper pressure, and obtained a good yield of lubricating hydrocarbons. Nash, Stanley, and Bowen[5] examined the results of Otto and found this lubricating oil of inferior quality because of its high-temperature coefficient of viscosity and its instability in the presence of atmospheric oxygen. Sullivan, Vorhees, Neely, and Shanklard[6] treated cracked distillates of paraffinic base

(Continued on Page 123)

(Continued from Page 120)

with aluminum chloride and obtained lubricating oils whose lubricating values were quite equal to those of the best natural oils.

Thus it is seen that for the purpose of producing synthetic lubricating oils, unsaturated hydrocarbons must first be formed. Instead of dehydrogenating the saturated hydrocarbons, halogens can be introduced into the molecule of saturated hydrocarbon, and the halogenated products can be condensed with other compounds. The first experiment of this type was made by Zeller and Gmelin[7] who submitted thinly liquid mineral oils to the chlorination process, and then treated the chlorinated products with concentrated sulphuric acid. The action of this acid caused a splitting up of the hydrochloric acid gas. The remainder, that is, the active split olefins, polymerized during the process into highly viscous lubricating oils. Recently, Tanaka, Kobayashi, and Furunato[8] chlorinated solid paraffin waxes, and thereby produced very satisfactory lubricating oils. Interesting studies have been made by numerous investigators concerning combination of open-chain hydrocarbons with those of cyclic structure. The first studies were purely of a scientific character but the results gave new ideas concerning formation of lubricating oils from other hydrocarbons.

Kraft prepared synthetic cetylic benzol (C_6H_5-$C_{16}H_{33}$) and octadecyl benzol (C_6H_5-$C_{18}H_{37}$) by allowing benzol to react with the proper hydrocarbon. Kraft described these compounds as good crystallizing hydrocarbons, cetylic benzol having a melting point of 27 deg. cent. and octadecyl benzol 36 deg. cent. Sabatiers[9] continued these studies, which led to the formation of the nonyl benzol, a colorless liquid. Halse[10] prepared 16 homologues of benzol from tertiary alcohols through the chlorides by means of the reaction of Friedel-Kraft, these hydrocarbons being colorless, viscous liquids having an aromatic odor. Halse submitted the alkyl benzols to a catalytic hydrogenation and obtained the corresponding alkylated homolgues of cyclo-hexane, these compounds forming also colorless liquids of a gasoline-like character.

Let us now discuss the condensation of dichlor paraffins and benzol to diaryl paraffins. Kraft describes a diphenylhexane in which two benzol rings are placed at the same carbon atom. This hydrocarbon forms large crystals having a melting point of 14 deg. centigrade. Braun and Deutsch[11] prepared a great number of diphenyl paraffins from monochlor-alkyl benzols. They produced diphenyl decane as a crystalline compound, and the diphenyl dodecane, as well as the diphenyl tetradecane, as a viscous and colorless liquid having a low freezing point. Thus it is seen that the combination of paraffin chains with one or two aromatic rings causes the formation of viscous liquids. Kramer and Spilker[12] studied this problem, being the first to succeed in the formation of highly-valuable lubricating oils and to explain their chemical constitution. Their procedure consisted in treating sterol, allyl alcohol, and aromatic hydrocarbons, such as toluol, xylol, and cumol, with concentrated sulphuric acid. According to Spilker the lubricating properties of the condensed products are caused by a proper combination of a greater number of aliphatic hydrocarbons with two or more cyclic rings. Of course, the point of addition of the hydrocarbon chain on the cyclic structure plays a very important part in the quality of the lubricating oil. Davis and McAllister[13] obtained smooth relationships between molecular volume and molecular weight for each type of series of hydrocarbons, and between molecular volumes and the number of naphthene rings in the molecule. They deduced an equation that permitted calculation, for any aromatic-free oil, of the percentage of the total number of the carbon atoms that is in naphthene rings.

According to the above-mentioned considerations, either of two ways may be chosen: (1) the direct synthetic preparation of cyclic compounds with aliphatic hydrocarbons; (2) the transformation of hydrocarbons with open chains into cyclic compounds in the first phase, these compounds being then submitted to a chemical reaction with aliphatic hydrocarbons.

The first method of preparing synthetic lubricating oils is of no value for the refining industry due to the fact that the petroleum products, as well as the natural gas, contain little if any cyclic compounds. Of course, this method would be of great interest to the coal industry in the transformation of coal into liquid products, because the split compounds of the coal are rich in aromatic and naphthenic compounds.

In the oil refining industry only the second method could be taken into consideration. In this case the transformation of hydrocarbons with open chains into cyclic hydrocarbons must be done artificially. In other words, it is necessary to submit the $=CH_2$ molecules to the action of high temperatures at which the active linkages will act in the middle of a chain of three or more $=CH_2$ molecules. In earlier literature the opinion was expressed that aromatic compounds are formed only at extremely high temperature. The free-energy relationships, however, indicate that aromatics are formed from certain olefins of low molecular weight, at a temperature as low as 800 deg. fahrenheit.

When polymerizing at comparatively low temperatures and high pressures the addition of $=CH_2$ molecules to open chains seems to prevail, while at higher temperatures the combination of a certain amount of $=CH_2$ molecules seems to take place, leading to the formation of cyclic compounds. The high temperature polymerization condensate is almost completely aromatic.

Viewing this problem in the light of the above, we reach the conclusion that a double process must be carried out to favor the simultaneous formation of aromatic and aliphatic hydrocarbons, these compounds being then submitted to the second process in which a proper combination of the above-mentioned hydrocarbons results in the formation of lubricating oils.

For this purpose either of two methods may be chosen: (1) the production of lubricating oils from gaseous hydrocarbons by means of the method of Fischer and Tropsch; (2) the production of a mixture of gasoline and lubricating oils by the direct pyrolysis of the gaseous hydrocarbons.

According to the method of Fischer and Tropsch, a properly active gas must be produced, this gas being transformable into hydrocarbons of a lubricating character. Olefin gases may be directly submitted to this process; but when natural gas is used, it first must be transformed into an active state. Fischer and Tropsch propose the changing of natural gas into an active form by means of superheated steam, this process resulting in the splitting of the inactive methane and water into carbon monoxide and hydrogen, according to the following reaction: $CH_4 + H_2O \Longrightarrow CO + 3H_2$. This active gas, the so-called splitting gas, requires a special purification for the removal of the traces of hydrogen sulphide and other deleterious compounds. For this purpose a proper catalyst must be used; but before entering into this matter, let us consider the reaction processes of the above-mentioned splitting gas. It is evident that to produce lubricating oils from the splitting gas, this mixture, consisting of CO and H_2 must first be transformed into olefin hydrocarbons. The catalyst plays a very important part in all reactions. For example, when cobalt or nickel are used, quite different results are obtained in the formation of olefin hydrocarbons.

Cobalt is considerably stronger in its activity than is nickel. In other words, cobalt produces twice the quantity of olefins that nickel does. Of course, the volume of hydrogen in the splitting gas also plays a very important part in the formation of olefin hydrocarbons. When carbon monoxide and hydrogen are present in the splitting gas in the proportion of 1 to 3, the quantity of olefins formed will be less than when the proportion is 1 to 1. Table 1 gives the results of the action of cobalt and nickel on the splitting gas of different mixture.

TABLE 1

Catalyst	*Formation of olefins Vol. Percent*		
	1:1	1:2	1:3
Cobalt	58	34	11
Nickel	32	15	6

It is seen from Table 1 that the action of cobalt on a mixture of one molecule hydrogen and one molecule carbon monoxide causes the formation of 58 percent olefins, while the same catalyst when acting on a mixture of one molecule of carbon monoxide and three molecules of hydrogen forms only 32 percent olefins. The volume of olefins produced is less when nickel is used, and may even decrease to six percent.

These phenomena are of great importance because it makes it possible to regulate the proportion of the hydrocarbons formed. As mentioned, the amount of hydrogen in the split gas influences to a very great degree the formation of olefin hydrocarbons, that is, the more hydrogen in the split gas the less the yield of olefin hydrocarbons.

As the gas when split contains three parts of hydrogen and one part of carbon monoxide, it is evident that only a small amount of olefins would be formed. Thus, according to the method of Fischer and Tropsch, gas split from natural gas is valuable only in the formation of saturated hydrocarbons because of the hydrogen excess. To lower the amount of hydrogen from such a split gas, Fischer proposes the action of carbon dioxide, according to the reaction:

$$CH_4 + CO_2 + H_2O \longrightarrow 2CO + 2H_2 + H_2O.$$

This reaction leads to an increase of active carbon monoxide and a decrease of hydrogen. In this case equilibrium is reached between one molecule of carbon monoxide and one molecule of hydrogen; however, the use of carbon dioxide would be a very uneconomical process in the oil-refining industry, because a great amount of this expensive gas would have to be used.

When comparing Fischer's activation of natural gas by means of the split oxygen atoms from the water to the theory of the author[14] the existence of the unstable active $=CH_2$ hydrocarbons must be admitted. Fischer indirectly forms $=CH_2$ molecules by causing a formation of carbon monoxide, a compound having two free active linkages. In the moment that two hydrogen atoms go into chemical reaction with the molecule of carbon monoxide, the oxygen will be split from the nucleus. Thus the $=CH_2$ molecules are formed in the first phase. In the second phase the $=CH_2$ molecules are converted into different hydrocarbons. In case a great excess of hydrogen particles takes part in this process, the saturated hydrocarbons will be produced. Therefore, it is necessary to extract a part of the hydrogen from the split gas before submitting it to the polymerization process.

For this purpose this split gas should be submitted to an oxidation process, in which temperature and pressure favor the chemical addition of the hydrogen only, leaving the carbon monoxide unattacked. In this process a proper catalyst should be chosen. The catalyst is mixed in a special reaction chamber with the hydrocarbons to be oxidized, and the mixture then heated to a proper temperature under a favorable pressure. Then the split gas under proper temperature and pressure is allowed to flow into the reaction chamber. A part of hydrogen will be removed from the split gas, the gases left being poorer in hydrogen particles.

As mentioned, temperature and pressure play a very important part in the removal of a certain amount of hydrogen from the split gas, as well as in the reaction between the unstable carbon and hydrogen atoms. Of course, the temperatures depend to a large extent upon the kind of catalyst used. For example, the synthesis of gasoline-like hydrocarbons requires a temperature of 250 deg. cent., when iron is used as a catalyst, although when using cobalt, the temperature of 180 deg. cent. is sufficient for the same reactions. Gas mixtures rich in hydrogen require the use of lower temperatures, while mixtures poor in hydrogen must be submitted to higher temperatures. In other words, the following factors play a very important part in the polymerization processes of pyrolysis and destructive hydrogenation: pressure, temperature, catalyst, and the amount of hydrogen in the gas mixture. Increase in pressure causes the formation of split hydrocarbon molecules, while increase of temperature favors the formation of methane and carbon.

The catalysts in the series Fe, Co, Ni cause the saturation of the split particles, that is, the yield of the olefins decreases. On the contrary, the diminution of the hydrogen content leads to the formation of olefins. Iron requires a higher temperature than cobalt. When using cobalt, the reaction is as follows: $CO + 2H_2 \longrightarrow =CH_2 + H_2O$, but iron gives quite a different reaction: $2CO + H_2 \longrightarrow =CH_2 + CO_2$.

This letter reaction gives considerable trouble because the carbon dioxide must first be submitted to the action of a copper catalyst before the gas mixture is directed to the reaction chamber. This action causes splitting of the carbon dioxide into carbon monoxide and water, the water then being removed from the gas mixture. This process may be considered as very uneconomical. It can be seen from the above that cobalt gives the best results in the formation of $=CH_2$ molecules.

Thus the above-mentioned factors may produce two sorts of liquid hydrocarbons: (1) a liquid the major part of which is olefins, this liquid consisting of gasoline-like hydrocarbons; (2) a liquid the major part of which is saturated hydrocarbons of gas-oil character.

In this article the second liquid, that having gas-oil properties, is considered for the synthesis of lubricating oils. According to its specific gravity, elementary composition, and boiling point, this liquid can be considered as $C_{18}H_{38}$. According to earlier-mentioned theories concerning the chemical constitution of natural lubricating oils, being of cyclic structure combined with aliphatic hydrocarbons, the author has effected the combination of the above-mentioned liquid with a compound of cyclic structure. To favor this combination, chlorination has been carried out in this process. The substitution of hydrogen by the chlorine has caused no difficulties. The liquid was stirred during the chlorination process at a temperature of approximately 45 deg. centigrade. After a short time, the liquid became very viscous, indicating a very high chlorination of the liquid. The aluminum chloride then was added to the mixture of chlorinated material and aromatic compounds benzol, toluol, and xylols.

These processes have been carried out in the following manner: A part of the chlorinated material was mixed with two parts of a cyclic compound. To this mixture was added ten percent

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of aluminum chloride. The reaction began to occur at room temperature, and was accelerated by increasing the temperature. After an exact fractionation of the reaction product, and treatment with a bleaching clay, an oil was obtained that had a high lubricating value. Of course, the specific gravity of the product depends to a great extent upon the chlorine content of the molecule. The more chlorine in the molecule, the higher the specific gravity of the product. The reason for this is that the split atom chlorine causes the formation of the bonds C-C in the condensation molecule, leading to a more compact linking of the atoms in the nucleus. With the increase of specific gravity the viscosity of the product increases proportionally.

The aluminum chloride is now combined, that is, it no longer exists in a free state but is bound with certain hydrocarbons to form a complex compound; however, this complex compound may be used in the reaction processes, and it is very remarkable that the use of this complex catalyst results in the formation of lubricating oils considerably more viscous than those produced when fresh aluminum chloride is used. Therefore, it is necessary to choose a proper ratio of used aluminum chloride to fresh aluminum chloride to produce a product of the desired viscosity. The explanation of this phenomenon seems to consist in the cooperation of the complex aluminum chloride compounds.

Now, the determination of the composition of the chlorinated products would be of great interest; however, it is complicated because the aluminum chloride removes a certain amount of the active components during the process to form complex compounds; furthermore the liquid hydrocarbons contain different types of hydrocarbons of different boiling points. Practically, as has been stated, the molecular weight of the higher-boiling polymerized hydrocarbons is approximately 500.

Viewing the process of Fischer in the light of the above, we are forced to the conclusion that this method encounters numerous difficulties in the oil-refining industry; the natural gas must be transformed into the active form of water gas; moreover, aromatic homologues must be introduced into the formed olefin hydrocarbons to obtain synthetic lubricating oils. Of course, a much more economical method would be the transformation of natural gas into olefin hydrocarbons on the one hand, and changing of the other part of the same gas into aromatic compounds before submitting them to the proper polymerization process.

Changing olefin hydrocarbons into aromatic compounds long has been a subject for experimentation. Davidson[15] accomplished experimentally the transformation of olefins into aromatic hydrocarbons according to the following reactions:

(1) $2C_2H_4 \rightarrow C_4H_6 + H_2$;

(2) $C_4H_6 + C_2H_4 \rightarrow$ cyclo-hexane;

(3) Cyclo-hexane $\rightarrow$ benzol $+ 2H_2$. Wood[16] carried out a pyrolysis of ethylene at a temperature of approximately 700 deg. cent. and obtained 25 percent benzol and 21 percent asphalt. The remaining gas contained only ethylene and butadiene. Schneider and Frohlich[17] believe that ethylene plays a very important part in the synthesis of lubricating oils. According to their opinion, the ethylene is transformed during pyrolysis into butadiene, this butadiene then uniting with hydrogen and the resulting chemical reaction forming aromatic hydrocarbons. It is seen then, that butadiene is a very important component in the formation of aromatic compounds. When olefin gases are free of butadiene, proper conditions must be established to cause the formation of this intermediary compound. According to the above-mentioned opinions, the following final reactions seem to occur during the pyrolysis of paraffin and olefin hydrocarbons:

1. Paraffin compounds $\rightarrow$ olefins + hydrogen,
2. Paraffins + olefins $\rightarrow$ low boiling paraffins,
3. Olefins + olefins $\rightarrow$ di-olefin + hydrogen,
4. Di-olefin + olefin $\rightarrow$ cyclo-olefin,
5. Cyclo-olefin $\rightarrow$ cyclo-di-olefin + hydrogen,
6. Cyclo-di-olefin $\rightarrow$ aromatics + hydrogen.

Of course, all these reactions are the results of intermediary $=CH_2$ polymerizations. When polymerizing $=CH_2$ molecules at a high temperature, the active linkages will act in the middle of a chain of three or more $=CH_2$ molecules. The result is that when the temperature is increased and the pressure lowered the mutual active linkages of the polymerized $=CH_2$ molecules will enlarge their activity, resulting in the formation of cyclic hydrocarbons.

For this purpose a proper catalyst must be used, to be able to close the $=CH_2$ molecules into cyclic hydrocarbons. An alloy of cobalt, nickel, and silicon has been found to be the best catalyst for this purpose. To produce aromatic hydrocarbons from olefins a temperature of 700 deg. cent., and a pressure of six atmospheres must be used. Of course, when using natural gas, it first must be submitted to a pyrolysis to split the saturated hydrocarbons into the $=CH_2$ molecules[18]. Such a split gas when submitted to the above-mentioned conditions yields:

Aromatic hydrocarbons ..... 75%.

Olefins ..... 15%.

Paraffin and cyclic hydrocarbons 10%.

This mixture can be used in the synthesis of lubricating oils. As raw material for chlorination the author recommends the residuum obtained by the fractionation of the polymerization distillate. The chlorination and condensation occurs in the manner already mentioned. This method led to the formation of oils of high lubricating value. Comparing the properties of the synthetic lubricating oils to those of natural oils, it can be said that the synthetic oils show a higher specific gravity and a relatively low viscosity index. The synthetic oils also present a much higher stability toward oxidation.

Summarizing, it can be said that the manufacture of oils of too high viscosities causes some inconveniences, including the deterioration of the other properties; therefore the author suggests carrying out the chlorination until the trichlor is produced.

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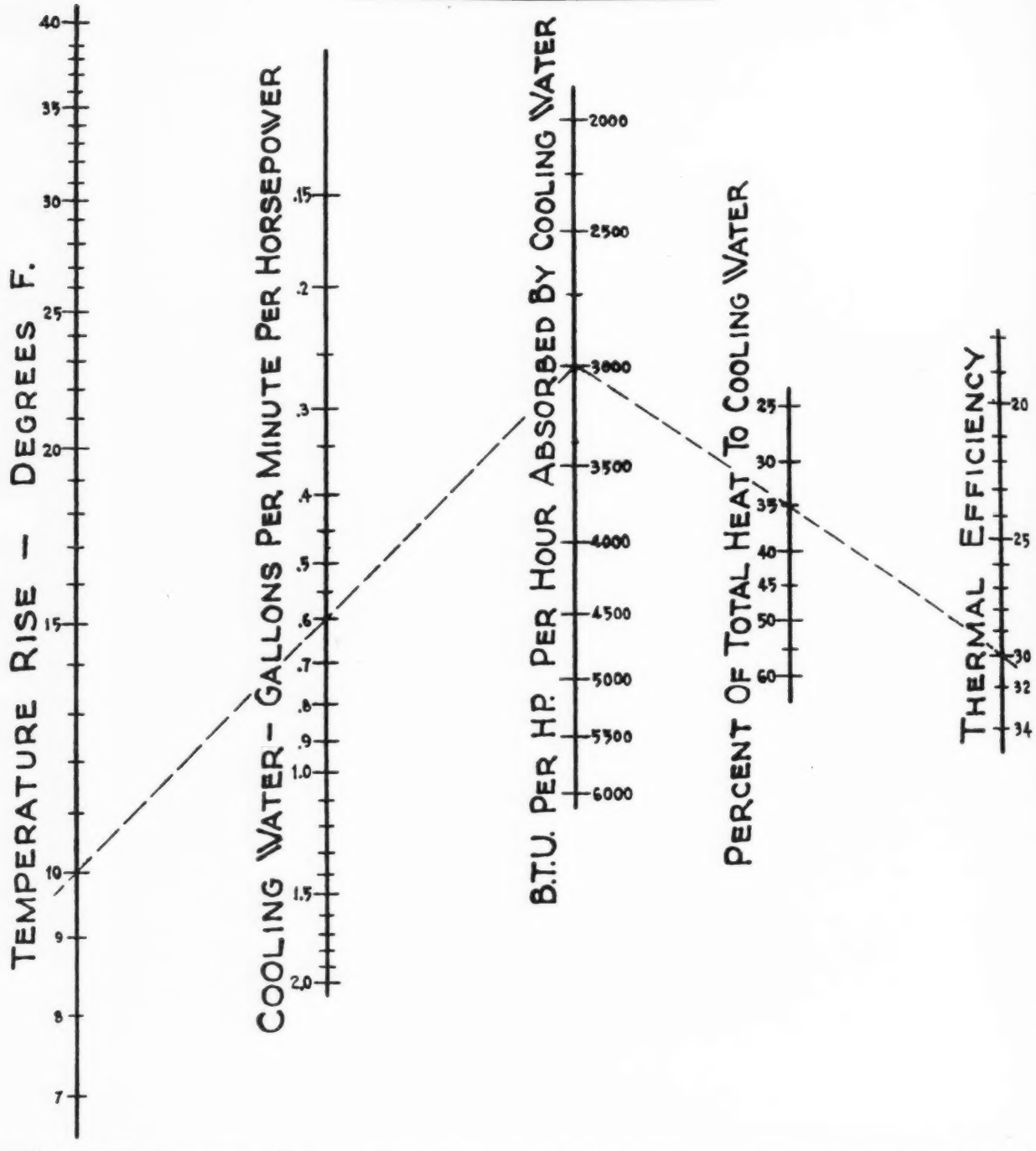
Alignment Chart for Estimating Engine Cooling Water Requirements

By FRANK E. HANGS



THE thermal efficiency of all Diesel engines is about 30 percent; of small gas engines, as low as 20 percent; of large gas engines, 25 percent. These values may be used for estimation.

The proportion of the heat rejected to the cooling water depends upon engine design, especially the extent of jackets around the exhaust manifold, upon whether the pistons are cooled, and whether there are lubricating oil coolers. Many handbooks give 35 percent; however, in practice some gas engines may reject a total of 50 percent to cooling water. It is well to use 40 percent or more to be on the safe side.

Modern practice is to allow 10 to 20 deg. rise in the cooling water temperature. A high velocity of flow induces good heat transfer and water is not so likely to form scale as when the flow is of low velocity. A temperature difference greater than 20 deg. puts undue expansion strain on the cylinder head and other engine parts.

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LAUGH WITH BARNEY

Edited by BARNEY HORRIGAN

Circumstances Alter Cases

An old negro mammy had six or seven children, and among them was one that was light yellow, and he rather lorded it over the balance of the bunch, which stirred up lots of quarrels. One day his mammy says:

"Look here young sprout, I'se gonna take a barrel stave and flail the daylights out o' you if you don't behave, and I want to tell you that if I hadn't got behind with my insurance you would be as black as any of the balance."—Submitted by Roy Lundy, of the Tulsa Rig, Reel and Manufacturing Company.

* * *

He (on phone): Hello, what are you doing?

Feminine Voice: Getting ready for church.

He: Sorry. Wrong number.

—*Pelican.*

* * *

Prize Relief Letter

Government agencies receive all sorts of relief letters, but here is the prize letter:

"My husband was induced into the WPA 18 months ago and I ain't got no pay since he was gone. Please send my elopement as I have a four month old baby and he is my only support and I kneed every day to buy food and keep up in clothes. I am a pore woman and all I have is one. Both sides of my parents are very old and I can't expect anything of them as my mother has been in bed for 13 years with one doctor and she won't take another. Do I get any more than I am going to get? Please send me a letter and tell me if my husband made application for a wife and child and please send me a wife's form to fill out. I have already wrote to the president and got no answer and if I don't hear from you I will write Uncle Same about you and him . . ."

* * *

A man was once caught by his Mrs.
To the maidservant giving some Krs.
On perceiving his plight,
He suggested in fright:
"What a most inconvenient mess thrs."

* * *

"Mamma, why does the furnace make Daddy shiver and make funny faces and hiccup when he comes up from the cellar?"

Two friends met. One of them remarked on the dirty state of the other's hands.

"Why," he exclaimed, "your hands are covered with soot!"

"That's because I was down at the station seeing my wife away," replied the friend.

"But how does that affect your hands?"

"I patted the engine."

* * *

Gene Cruse has always contended that he was not the fattest man in this division and steps on the scales at every opportunity to check up on his theory. However, recently, while in Evansville, he was given quite a shock. He saw a new type of scales that calls out your weight instead of showing it on the usual dial. Gene looked it all over then put his penny in the slot, climbed on, and the scales sang out, "One at a time, please."—*The Beacon* (The Ohio Oil Company).

* * *

One of the patients at the asylum decided to test another, to see if he was really as sane as he claimed to be. Putting his hands behind him, he asked, "What am I holding in my hand?"

"A horse and wagon," piped the other.

"Aw," said the first one hotly, "you cheated! You saw me pick it up!"

* * *

He: How's your companionate marriage coming on?

Him: Not so good. I lost my wife's address.

* * *

The office drudge says that he has just looked up a book of omens and signs and found, just as he expected, that his birthstone is the grindstone.

* * *

"Say, Jim, you've been going with Mary now for three years. Why don't you marry her?"

"I've thought about that, but if I did, where would I spend my evenings?"

* * *

And then there was the condemned golfer who asked the hangman, "Mind if I take a couple of practice swings?"

* * *

Patient: What's this extra item of ten dollars on my bill?

Doctor: It's for my glasses—I lost them while operating on you.

"Did you give the man the third degree?" asked the police officer.

"Yes, we browbeat and badgered him with every question we could think of"

"What did he do?"

"He dozed off and merely said now and then, 'Yes, my dear, you are perfectly right'."

* * *

A young man whose first job was that of reporter on a newspaper was having trouble writing his stories. All his efforts seemed to find their way into the trash basket.

One day the City Editor called him and said: "Look—you don't quite know what the public is interested in, you don't sense what news really is. For example, if a dog bites a man, that isn't news. But if a man bites a dog, that's news."

The next day the reporter submitted a story under the following headline:

FIRE PLUG BREAKS—WETS DOG!

* * *

Two spinsters were discussing men.

"Which would you desire most in a husband—brains, wealth or appearance?" asked one.

"Appearance," snapped the other, "and the sooner the better."

* * *

A true lover of music is a man who, upon hearing a soprano voice in the bathroom, puts his ear to the keyhole.

* * *

Chief of Police: Well, I hope you people are putting on a clean show?

Showman: I'll say, Chief—why, we even gotta scene where the' girls take a bath right on th' stage!

* * *

Political Speaker: I'm pleased to see this dense crowd here tonight.

Voice from the Back: Don't be too pleased. We ain't all dense!

* * *

The proof that two can live as cheaply as one is demonstrated by the horse and the sparrow.

* * *

The magazine subscription man was met at the door by the colored girl.

"I would like to see the lady of the house," he said.

"Lawsy, I specs you would—she's takin' a bath."

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Running Tour
WITH MEN IN THE INDUSTRY

WILLIAM V. VIETTI, Houston, Texas, senior petroleum engineer of The Texas Company, has been named manager at Bogota, Colombia, of The Texas Petroleum Company, a subsidiary. **C. B. WILLIAMS,** assistant manager of the West Texas Division of the same company, who has had his headquarters at Fort Worth, is being transferred to Cucuta, Colombia, as manager in charge of development and production of the Colombian Petroleum Company. **J. K. HUFENDICK,** Wink, Texas, drilling superintendent in West Texas, has been made field superintendent for the Colombian Petroleum Company on the Barco concession. **ROY WIGHT** has been named successor to Hufendick. Successors to the other two men have not been announced.

L. E. DePEW has been appointed foreman of the Shamrock, Texas, district of the Lone Star Gas Company, Pipe Line Department, succeeding **W. K. WEAVER,** resigned. He has been assistant foreman in the Pueblo district, where he has been succeeded by **JAMES A. JARBOE,** assistant foreman of the Ranger district.

M. W. BOVAIRD, of the Bovaird Supply Company, and **MRS. BOVAIRD,** in company with **F. E. McMILLAN,** of the Louall Drilling Company, and **MRS. McMILLAN,** have left on a 16-day cruise from New Orleans, thence to Havana and Panama and return. They will be gone about three weeks, returning to Tulsa, Oklahoma, the latter part of February.

H. M. HOHMANN and **L. D. MINNIGH,** of the Bataafsche Petroleum Maatschappij, have returned to their headquarters at The Hague, Holland, after being in the United States for two months studying oilfield conditions.

R. C. STONER, who has been general manager of the producing department of the Standard Oil Company of California, has been elected a director of the company. His vacated post has been taken over by **WALTER G. BLACK,** and **FLOYD S. BRYANT** is Black's assistant.

FRANCISCO RAPPALLINI, administrator for the Yacimientos Petroliferas Fiscales in Plaza Huincul, Argentina, and **SOCRATES BROULLON,** manager of the Division of Production in Comodoro Rivadavia, have been in the United States making a study of drilling and production practices.

PAUL L. VAUDOIT is now practicing as a consulting petroleum engineer, his temporary headquarters being 2229 Del Monte Drive, Houston, Texas. During the last 11½ years he has been a petroleum engineer with the Shell Petroleum Corporation in the Gulf Coast areas of Texas and Louisiana, making his headquarters at Houston. At one time Vaudoit was on the staff of the U. S. Bureau of Mines.

PAUL L. VAUDOIT

FRANK SEELY, general superintendent in the Texas Panhandle for the Royal Oil and Gas Company, has been transferred to Tulsa, Oklahoma, and placed in charge of the company's operations in Texas, Oklahoma, Louisiana, Kansas, and Arkansas.

W. H. EASTHAM, superintendent of the Oklahoma and Kansas divisions of the Sunray Oil Company, has been transferred to Wilmington, California, where he is in charge of the recently-established California production division of the company.

EVERETT R. FILLEY, Tulsa, Oklahoma, manager of production for The Texas Company in the Kansas-Oklahoma-Kentucky division, has been made assistant general manager of production of the company and transferred to Houston, Texas. **HAROLD N. PARDEE,** who has been assistant manager becomes division production manager. The new assistant division manager of production is **H. J. HEALD** from the Denver, Colorado, office.

H. M. RYDER, of the Ryder Scott Company, petroleum engineers, Bradford, Pennsylvania, announces his company has moved its offices to the Oil Well Supply Company Building, 108 Main Street.

HAROLD C. ORAM and **EDWARD V. WALKER,** with the Attock Oil Company, Ltd., Khaur, Punjab, India, would like to get in touch with **C. R. "RAY" OWEN,** who was with the Carter Oil Company in Seminole, Oklahoma, in 1931-32.

R. B. BOSSLER, petroleum engineer of the Brundred Oil Corporation, Oil City, Pennsylvania, has been named chairman of the Production Advisory Committee of the Pennsylvania Grade Crude Oil Association. He succeeds **COY C. HOGG,** Titusville, who retains his membership on the committee.

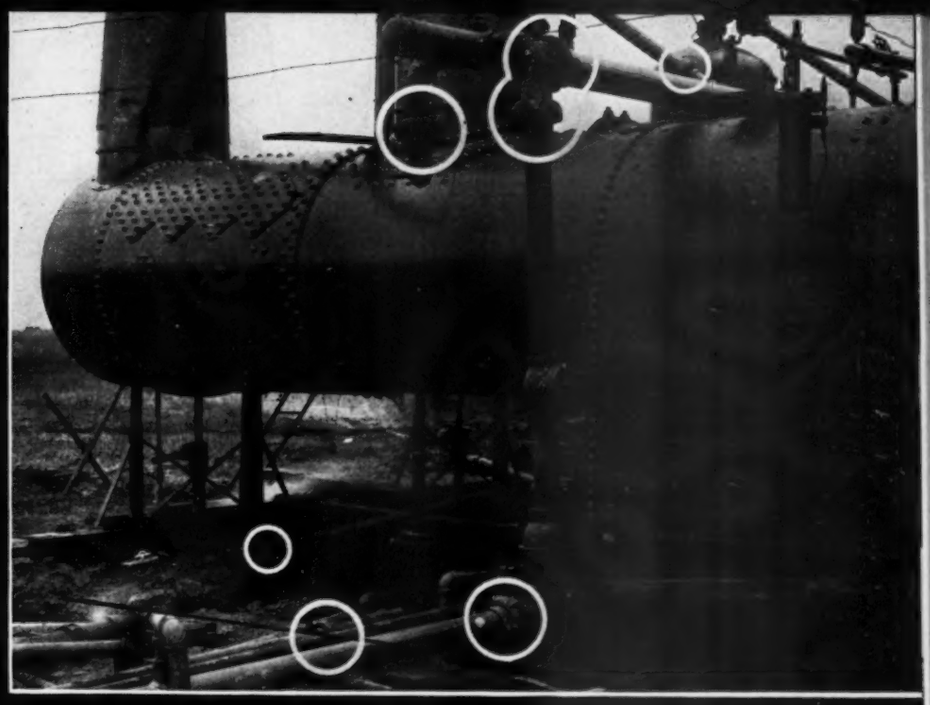
M. E. LOMBARDI, San Francisco, has been made a vice-president of the Standard Oil Company of California. He has been a director of the company since 1927.

BRUCE K. BROWN has been appointed general manager in charge of research and development for the Standard Oil Company of Indiana.

H. M. LYTELL has been placed in charge of field operations in Egypt by the Socony-Vacuum Oil Company. He formerly was with the General Petroleum Corporation in California.

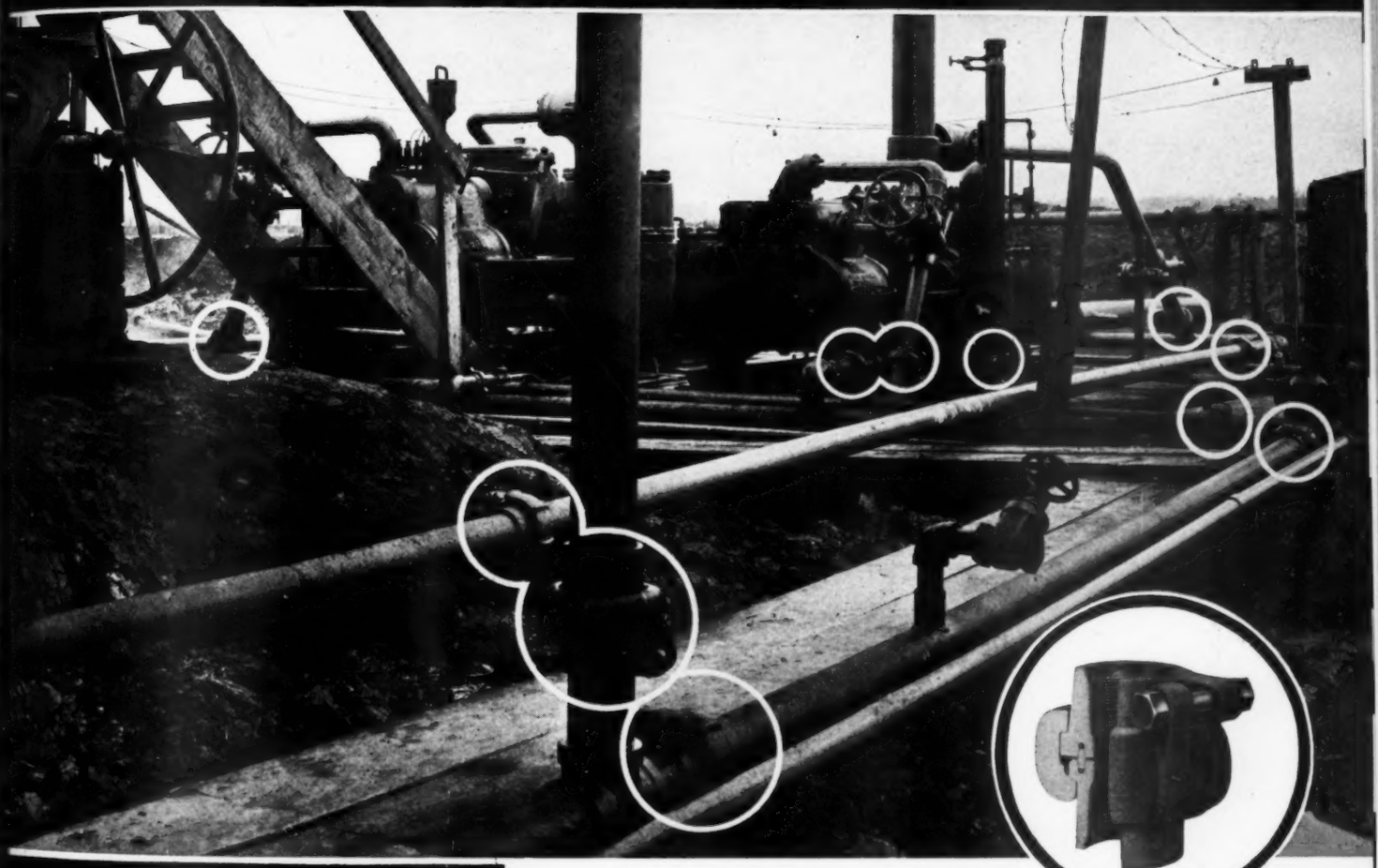
A. H. CALDERWOOD has been named manager of the Martinez, California, refinery of the Shell Oil Company, succeeding **E. D. CUMMING** who has been transferred to the Shell Petroleum Corporation offices at St. Louis, Missouri. Calderwood has been assistant manager of the refinery.

W. M. SMALL has been made general manager in Western Egypt for the Standard Oil Company of Egypt. In the past he has been with Standard Oil Company of New Jersey subsidiaries in Mexico, Argentina, and various European countries.



TYPICAL UNIBOLT APPLICATIONS

THAT ARE SAVING MONEY FOR COST-CONSCIOUS OPERATORS



High Pressure Steel UNIBOLT Coupling

THORNHILL-CRAVER CO.

Houston Texas

UNIBOLT
THE ONE BOLT COUPLING

BECAUSE—

They save hours of costly down time.
Rugged construction, interchangeable parts, and replaceable seat rings assure maximum salvage and long life.
Available in three types:

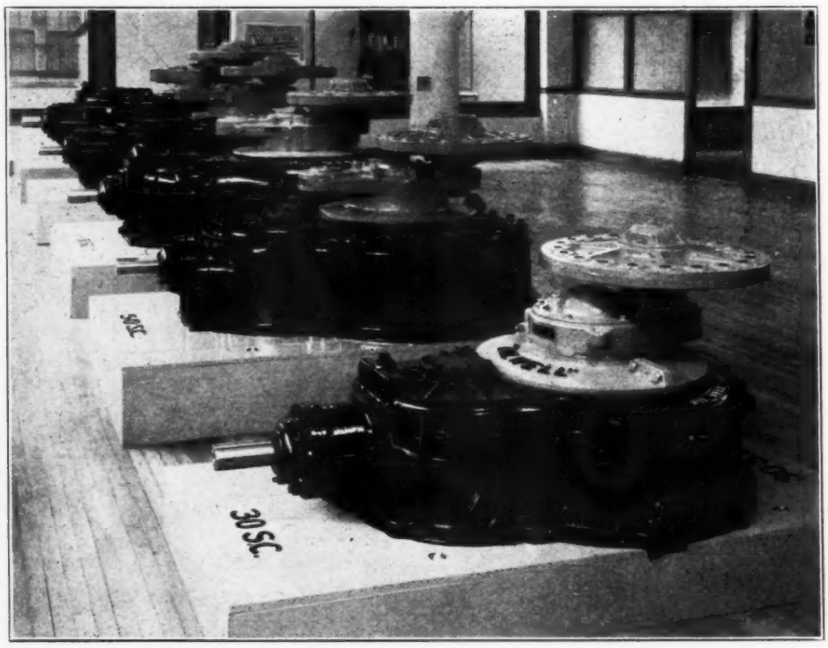
*6000-lb. test, steel—2", 2½", 3" and 4".
*2000-lb. test, steel—6", 8", and 10".
1000-lb. test, malleable iron—2", 2½", 3" and 4".

Blanking plugs available for all steel UNIBOLTS.

MACHINERY and EQUIPMENT

Complete Line of Oilbath Geared Powers Includes Five Sizes

FIVE sizes of oilbath geared powers, all of the same general design, comprise a very striking display now on exhibit at the Dallas office of Oil Well Supply Company. These five sizes comprise a complete line. The oilfield ratings at 20 s.p.m. are 30, 50, 80, 100, and 150 hp. and the Lewis Formula industrial ratings are 106, 172, 240, 385, and 510 hp., respectively.



In 1930, "Oilwell" constructed the first fully-enclosed, roller-bearing, double-reduction gear-driven power. This first unit was rated at 80 hp. for oilfield service. The addition of two larger and two smaller powers now provides an economical size for every central pumping requirement.

A feature of all sizes in the "Oilwell' line is the stationary-spindle construction. It provides direct transfer of side pull to the base and foundation rather than indirect transfer through the housing cover and the joint between the base and the cover. Another feature of this construction is the favorable bearing spacing between the crank pin and the upper spindle bearing and also between the upper and lower spindle bearings.

"Oilwell's" stationary-spindle construction makes possible the choice of two stroke-lengths with a single crank of minimum overhang. This dual-stroke arrangement is provided on all sizes but the smallest.

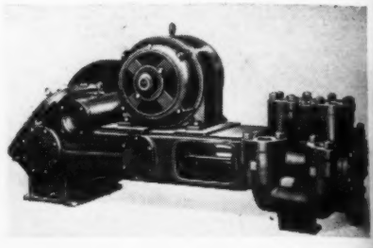
Other features of this complete line of geared powers include spiral-bevel and single-helical gearing, all bearings of heavy-duty tapered-roller type, positive and simplified lubrication, compact construction and high mechanical efficiency. All gears and pinions are precision-cut and heat-treated to insure ample strength and excellent wearing qualities.

Fairbanks-Morse Announce Line of Duplex Power Pumps

FAIRBANKS, Morse and Company has announced a new line of duplex power pumps having eight-cover side-pot type fluid ends and enclosed, self-oiling power ends with herringbone gears and large roller bearings.

These pumps were designed to meet every requirement for pumping water, oil, or other free-flowing liquid in quantities to 187 gal. per min. and at pressures to 1000 lb. per sq. inch. They are available as basic pumps, having pulleys for belt drive, or as complete, compact F-M motor-driven pumps covered by a single manufacturer's guaranty.

The eight-cover side-pot type of fluid end, with each suction and discharge valve readily accessible in its own valve pot, permits easy servicing. Individual valve pot covers are, of course, much more easily removed than are larger ones covering several valves. Fluid-end passageways are large and direct, offering low resistance to flow.



Quiet, efficient herringbone gears insure a smooth flow of power, with little vibration, from power end to fluid end, the manufacturers state. Generous crank-shaft and pinion-shaft roller bearings reduce mechanical friction to a minimum. The self-oiling construction employed in the power end assures positive lubrication of all gears, connecting-rod bearings, and crossheads, it is stated. There is sufficient space between the two removable-gland type stuffing boxes so that there is easy access for inspection or servicing, and so that no part of the piston rod enters both stuffing boxes. This prevents oil from entering the fluid end and water from entering the power end.

These duplex power pumps, Figs. 6184 and 6185, are fully described in Bulletin 6185, available upon request from Fairbanks, Morse and Company, 900 South Wabash Avenue, Chicago, Illinois.

The eight-cover side-pot fluid end is also available on the F-M Fig. 6285 duplex steam pumps, which have improved piston-valve steam ends.

LOOK at LIFE

in the oil well equipment industry—*thru the eye of Axelson's candid camera*

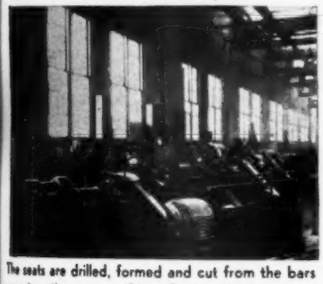
Axelson Deep Well Plunger Pumps are operating efficiently and economically in oil wells the world over. One of the important factors of plunger pump operation is the ball valves. This series of candid camera shots shows steps in the production of Axelson seats and balls, the care and precision with which they are made.

Alert oil men will recognize the outstanding features of Axelson production methods which make Axelson seats and balls as nearly perfect operating a ball valve as is possible to build in the world today.

The final inspection of Axelson seats and balls is made by Andrew Andris, who has been making and testing balls and seats in the Axelson plant for more than 18 years. The skill and experience of Axelson employees are important factors in the production of pumping equipment. Axelson's reputation in the oil industry today is built on unceasing efforts to build a better product.

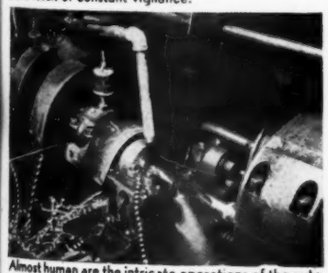
From flyge stocks of special alloyed, heat-treated steels Axelson seats are built to rigid specification. Samples from each bar are tested and inspected in the laboratory before they are accepted. Any deviation from Axelson standard means rejection.

Additional finishing is done in the turret lathes. Each operation is followed by an inspection to insure precision and uniformity. Improper machining results in rejection at any point during the process of manufacture. Care at every step assures few rejections.

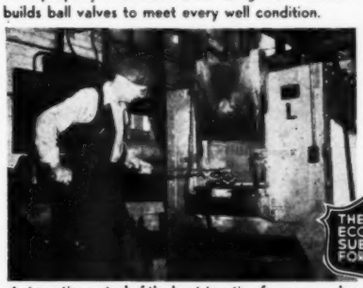


The seats are drilled, formed and cut from the bars on automatic screw machines. Each of the four types of Axelson seats starts its manufacturing operations in this way. The uniform high quality of Axelson products is the result of constant vigilance.

Imprinting name, size, material and code number. AXLOY and X-L seats are of corrosion-resisting steel. DURAX and ACME seats are of specially selected steel properly heat-treated for long life. Axelson builds ball valves to meet every well condition.



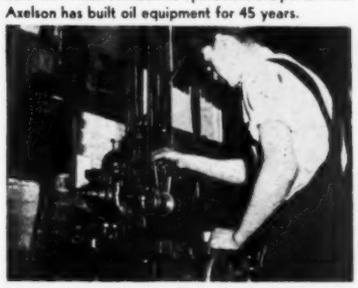
Almost human are the intricate operations of the automatic screw machines. Unlike human beings, these machines do not vary, once they have been set. Every seat is uniformly cut. Each one looks like the next, but all must pass individual tests.



Automatic control of the heat-treating furnaces makes possible production of seats of uniform hardness. Each seat is tested before and after heating to make sure it meets specification. Here Axelson seats get hardened for a long life in a deep well plunger pump.

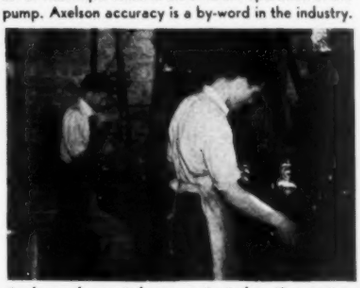
A powerful electro-magnet holds the seats in alignment as the faces are ground. Long-lived operation of Axelson seats and balls is due largely to the extreme care with which all machine operations are performed. Axelson has built oil equipment for 45 years.

Perfect contact between each seat and ball is accomplished by lapping in patented machines designed and built by Axelson for this operation. It is here that Axelson balls and seats become partners for greater pumping production.



Grinding the outside diameter of the seat and the face of the flange is a precision operation. On this depends the accurate centering of the seat in the valve, a matter of vital importance in the efficient operation of the pump. Axelson accuracy is a by-word in the industry.

The seal between both sides of each seat and its ball must be perfect. Here we see seats and balls being tested. The ball and seat must hold a high degree of vacuum over a period of time and must not leak.



Axelson valve seats have a patented seating contour which is accurately ground on special Axelson grinding machines by skilled workmen. This patented Axelson seating contour means better valve operation for a longer time under any well conditions.

Axelson seats pass chemical, mechanical and metallurgical tests. These tests assure the operator of a ball valve which will give maximum service in the well. Axelson AXLOY balls and seats are ready for a long and productive life.

THERE IS NO ECONOMICAL SUBSTITUTE FOR QUALITY

AXELSON

DEEP WELL PLUNGER PUMPS

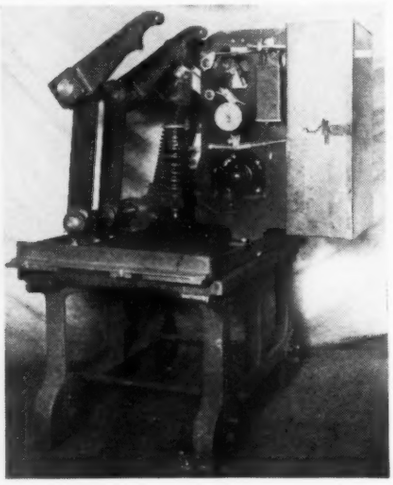
SUCKER RODS

Axelson Manufacturing Company, P. O. Box 98, Vernon Station, Los Angeles • St. Louis • 50 Church Street, New York • Tulsa

Mid-Continent and Eastern Distributor: Frick-Reid Supply Corporation • Rocky Mountain Distributor: Great Northern Tool & Supply Company.

Circuit Breaker Mechanism Is Cam Operated

A new circuit breaker mechanism has been developed by the switchgear division of the General Electric Company, Schenectady, New York, to supersede the centrifugal motor mechanism formerly used to operate Type FH oil-blast circuit breakers. Supplied for d-c. operation, the new Type ME-10 mechanism is a positive, high-speed, efficient, motor-driven cam device that operates smoothly, requires no close adjustments, and takes 4 in. less headroom than the old type.



The cam acts against a roller connected to a standard tripfree linkage. At the end of the closing stroke the motor is electrically disconnected, the excess energy of the cam is absorbed by a dashpot, and the cam is returned to starting position by a spring. Definite proportioning of closing force to closing requirements of the breaker provides high-speed closing without undue shock or over-travel at the end of the stroke. The high power supplies the force for compressing the springs required for high-speed opening.

Throttling Controller for Electric Furnaces

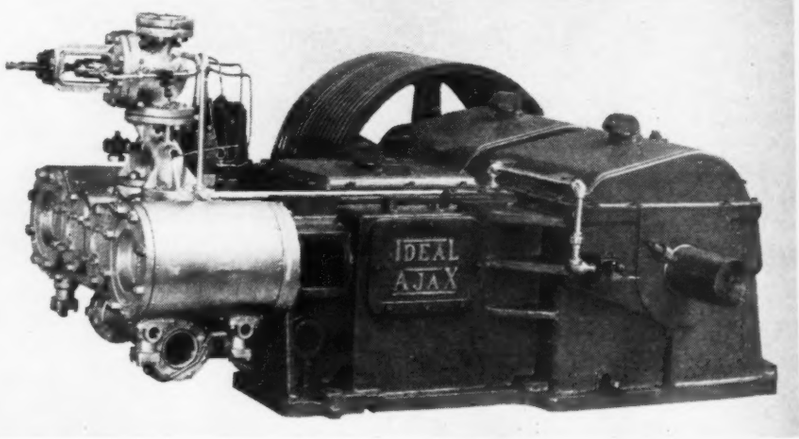
ECONOMICAL means for obtaining throttling control of electric furnaces and ovens are now available in a new Celectray indicating photoelectric controller. With this instrument no equipment is required other than that ordinarily used for on-and-off control, the makers state. This is an indicating potentiometric controller with photoelectric detection of the position of a light-beam reflected from a mirror galvanometer toward a reciprocating "controlling edge." With this automatic controller the heat supply is made to vary inversely as the temperature. The instrument has no measurable dead zone and holds a steady temperature instead of the oscillating temperature of on-and-off control. Life of the furnace switch or magnetic contactor is maintained by selecting the frequency of cycles according to the power requirements. The throttling zone can be readily adjusted within wide limits and the "load error" commonly met in throttling controllers can be kept within a few degrees without introducing appreciable hunting, according to the manufacturers. In many cases a precision instrument is required to detect any variation in temperature. Adjustment for load error is provided.

The equipment is manfactured by C. J. Tagliabue Manufacturing Company, Park and Nostrand Avenues, Brooklyn, New York.

Ideal-Ajax Announces 10 by 10½ Engine

THE new Ideal-Ajax 10 by 10½ horizontal twin-cylinder, roller-bearing steam engines are the two-throw, center-crank type with bored cross-head guides and with crank shaft running in tapered roller bearings. They are designed to run at moderate and high speeds and are built for heavy-duty, continuous service. They are compact and rugged, having a fully-enclosed frame and self-contained lubricating system.

A considerable saving in consumption of steam, fuel, and water results from the use of a 10 by 10½ Ideal-Ajax steam engine in connection with an Ideal C-350 power slush pump, for which this engine is particularly designed, the manufacturers state. When the engine is to be used for driving a power pump, usually it is supplied without reversing mechanism; however, double-throw eccentrics are provided, as with reversing-type engines, so that the engine can be converted easily into a reversing-type engine for other applications. This changeover can be made in the field and requires only a few new parts.

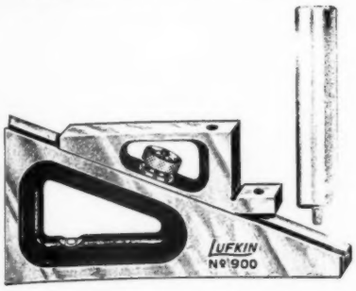


These engines are mounted on the extended skids of the power pumps and form a self-contained unit that can be handled easily in the field.

The pump-drive engines are regularly equipped to run "under" in order to give the proper rotation to the pump pinion shaft. The shaft is extended through both ends of the frame and the driving sheave or chain sprocket may be placed on either the right- or left-hand side. The shaft and bearings have sufficient size and capacity to withstand the severe pulls encountered in driving slush pumps. "V"-belts offer an efficient, quiet, and compact means of transmission between the engine and pump, it is stated. These belts are recommended by the manufacturers because of their ability to absorb shocks, their long service, and their resistance to heat and moisture. Belt adjustment is made possible by slotting the bolt holes in the base of the skid carrying the engine, and adjusting screws are used to take up the slack.

Power pumps can be operated at any desired speed and the engines will "stall" against a heavy overload caused by a plugged bit or any restricted circulation. To prevent an engine from over-speeding, the installation of an automatic, double-cushioned combination throttle and engine stop valve is recommended. By means of a small, simple, and positive shaft governor, which may be easily and quickly adjusted for any engine speed, the engine throttle is closed by a steam-tripped pilot valve. From remote points the valve may be tripped independently or closed by means of an emergency steam pipe connection, if desired.

Master Planer Gauge



A MASTER planer and shaper gauge has just been added to the line of precision tools offered by The Lufkin Rule Company, Saginaw, Michigan. It is known as a "Master" tool because it will properly handle many jobs beyond the customary limits of planer gauges, the manufacturers state.

Used as a planer gauge it greatly facilitates adjusting depth of first cut and setting tools for other cuts. Proper cut is obtained by setting the gauge to a micrometer, a surface gauge or caliper, then bringing the planer tool in contact with it. Using the extension, tool settings from ¼ in. to 9 in. can be made; without it, the range is ¼ in. to 6½ in., state the manufacturers.

The gauge serves also as an adjustable (sliding) parallel, because the upper face of the slide is extra long and slide and base are accurately fitted. It can be employed with a sine bar for grinding angles; also with gauge blocks for building up work on a surface plate and with an indicator for transferring measurements.

An important feature of the Lufkin Master Planer gauge is that the slot in which the slide travels is beveled as well as ground, the bevel preventing all side play when the slide is tightened, at any point, by a clamp nut.

This gauge can be used on base, on end or flat on either side, as both slide and nut are within the outside width of the base and both sides are ground square with the working edges. Base and slide are drop-forged steel, hardened. The base is ⅝ in wide, 5⅛ in. long, and fitted with a level.

With this No. 900 gauge a genuine mahogany case can be supplied.

Bardco Power Unit

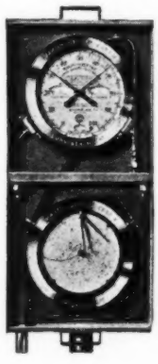
A NEW power unit for operators of compressors, pumps, hoists, welders, pump-jacks, and other oil-field and refinery equipment is being introduced by the Bardco Corporation of America, Los Angeles, California. The manufacturer states that power is produced by this new unit at a cost as low as ⅓ of a cent per hp. hour.

The unit is of compact design, and can be used either for stationary or

portable service. Choice may be had of a Ford V-8 engine or a Diesel engine, and in fuels a choice of natural or artificial gas, gasoline, distillate, butane, or Diesel fuel.

Features claimed by the manufacturer include the oversize oil re-refining unit that reclaims oil by eliminating carbon, excess dilution, and acid; and the automatic safety controls that warn of oil or water shortage. In an emergency the engine is stopped by the safety controls and they can be set to give a warning signal at any predetermined point.

A new bulletin, B-20, describes the Bardco Power Unit. For a copy write Bardco Corporation of America, 6670 Lexington Avenue, Los Angeles, California.



● The answer is easy when you drill with a Quintuplex, for this complete control instrument keeps a *continuous* 24-hour written record of all the important drilling functions.

Weight on bottom—torque on drill pipe—mud pump pressure—how long in the hole—how long on top—how much drilling time between connections . . . these are the important drilling facts you'll want to remember for future guidance. And these are the very facts that Quintuplex won't let you forget, for it writes them down the instant they occur!

But that's not all! Quintuplex also centralizes the five important drilling gauges—weight indicator, supersensitive weight indicator, torque, mud pressure, and rotary table r.p.m.—right under the driller's eyes where they're easy to watch and easy to read, yet not in the way.

If you're interested in greater drilling efficiency, look into the Quintuplex. There's an interesting booklet ready for you that fully describes this modern instrument. Write for it today!

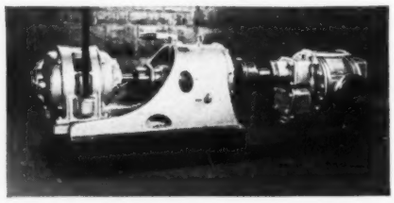
Do You Know?

If other items were taxed in proportion to gasoline, the tax on an ordinary home would amount to $4,000.

THE WEIGHT INDICATOR
MARTIN-DECKER CORPORATION
LONG BEACH CALIFORNIA
San Joaquin Valley: A. F. McQUISTON, Bakersfield, California
Mid-Continent Distributor: REED ROLLER BIT COMPANY, Houston, Texas

Liquids of Various Viscosities Handled by Pumping Unit

A COMPACT pumping unit for bulk transfer service when both thin and highly-viscous liquids are handled has been developed by Worthington Pump and Machinery Corporation of Harrison, New Jersey. The pump is of the herringbone-gear-impeller type driven by a constant-speed motor or internal combustion engine through a two-speed, enclosed transmission. For light liquids, the pump may be operated at high speed, and for viscous liquids the speed of the pump may be reduced. In either case,



the full power of the prime mover is employed.

In conventional applications of single pumping units on such service, motors are selected for the heaviest loads and are operated at a fraction of their rated power when pumping the thinner liquids. The new two-speed unit affords maximum efficiency because a relatively small constant-speed driver is used, the manufacturer states.

Acco-Morrow Pressure Lubricator

ON bearings, gears, and other moving parts of machinery where oil is needed, the Acco-Morrow Pressure Lubricator, recently announced by the American Chain and Cable Company, Inc., solves a perplexing and costly industrial problem by supplying lubrication at pressure up to 1000 lb., according to the manufacturers. Such pressure lubrication flushes out grit and dirt from a machine and at the same time forces oil into bearings.

The "Oilingseal" tip, made of compressible composition, is one of the outstanding Acco-Morrow Pressure Lubricator features. This tip makes a pressure-tight contact on the top edge of any common oil hole and practically all sizes and types of cups and oil hole covers in general use, it is stated, no special fittings being needed.

Operating directions are simple and effective. "Just put the 'Oilingseal' tip into the oil-hole; make firm contact, then push plunger slowly." There are no complicated parts. All active parts are made of brass or steel, and machined accurately.

The American Chain & Cable Company, Inc., of York, Pennsylvania, announces four gun-type Acco-Morrow Pressure Lubricators supplying pressure greater than 1000 lb. and six other models supplying pressure greater than 500 lb. are now being manufactured. Literature describing the Acco-Morrow Pressure Lubricator in detail can be obtained by addressing an inquiry to the manufacturers.

A BEAR FOR WEAR
GRIZZLY
SAVE WIRE LINES AND SAVE MONEY
The Grizzly "No-Wip" Line Saver will pay big dividends by reducing wire line wear to minimum—saving miles of valuable wire lines every year. Also reduces the extreme hazard of worn lines. Simplifies spooling; prevents whipping or piling on drum; floats with the line. A thoroughly engineered device, well built of the finest materials. Can be suspended at any point in the derrick. See it at your supply houses.
Not a rigidly controlled guide—it takes out the whip without straightening or injuring the line.
E. M. SMITH COMPANY
600-650 South Clarence Street, Los Angeles, California, U. S. A.
Complete Stocks Maintained in Our Warehouses At: 2311 West Street, Houston, Texas. 1008 S.E. 29th Street, Oklahoma City, Oklahoma. Export Office: Continental Emsco Co., 30 Rockefeller Plaza, New York City. DISTRIBUTED BY LEADING SUPPLY COMPANIES.
GRIZZLY No Wip LINE SAVER

Dale Cement Dump

DALE Service Corporation, 3520 Schaeffer Street, Culver City, California, is now marketing the Dale Cement Dump, a new type of bailer bottom designed to dump cement in a well at any desired level without dilution of the cement mix by the well fluid.

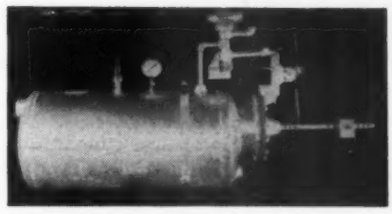
The chief advantage to the operator claimed by the manufacturer is that the Dale Cement Dump has an unusually free dumping action that enables the cement to displace the well fluid without becoming mixed with it as the bailer is raised. Thus, the cement mix is not diluted or contaminated by the muddy or oily well fluid, and the whole column of cement is said to set up in a very compact mass with uniform and exceptionally high strength.

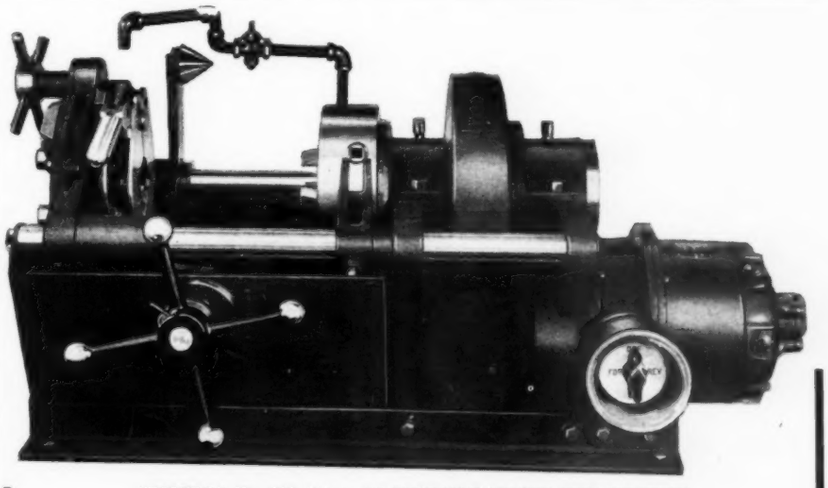
Construction of the Dale Cement Dump is such that the cement emerges from the extreme bottom of the body, through a hole that is the same size as the full inside diameter of the bailer bottom. There are no valves or orifices inside the body to restrict the flow of the cement from the bailer, it is pointed out, thus the danger of the cement bridging in the bailer and being later released accidentally as the bailer is being pulled to the surface is eliminated.

The Dale Cement Dump consists of a tubular body that can be attached to the lower end of a bailer made up of regulation tubing or casing. While being run into the hole the opening in the lower end of the cement dump is closed by a thin disk that serves to retain the load of cement. The disk is held in place by pivoted trip levers attached to the body. The trip levers are actuated by a sliding collar encircling the body, attached to replaceable friction springs of the proper size to contact the wall of the casing or liner in which the cement is to be dumped. This method of dumping enables the operator to trip the mechanism at any point he desires, and prevents accidental dumping while running in the hole.

B. S. & B. Automatic Blow Case

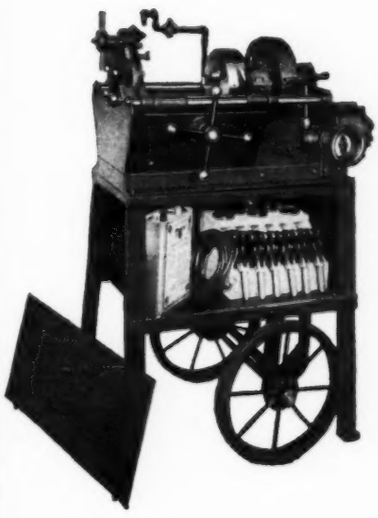
BLACK, Sivalls and Bryson, Inc., Oklahoma City, Oklahoma, announces improvements to its automatic blow case, equipment designed to prolong the flowing life of wells. The blow case is installed on wells when the separator pressure declines to such degree that it is insufficient to lift the liquid into the stock tanks. In operation, the oil gravitates from the separator to the blow case, filling it. A float rises and trips a valve gear that allows gas to enter from the residue line. The gas pressure thus built up forces the oil into the stock tanks. Check valves prevent return flow. As the float falls, the gas is vented into the separator. A counter can be employed to record the dumps. The blow case also provides an efficient automatic drip for gas lines under vacuum, the makers state.





"TOLEDO" No. 999 ½" to 2" PORTABLE POWER PIPE MACHINE

ALL PIPE UP TO 2-INCH . . .



. . is handled efficiently with a "TOLEDO" No. 999 Portable Power Pipe Machine.

2" pipe is threaded in 22 seconds and cut off in 10 seconds. Separate quick-opening die head and dies for each size assures instant die change and smooth, standard taper threads. Four blade cut-off. Cone-type fluted reamer.

The ideal, small portable power pipe machine. Full details sent on request.

THE TOLEDO PIPE-THREADING MACHINE CO.
TOLEDO, OHIO — NEW YORK OFFICE, 72 LAFAYETTE STREET

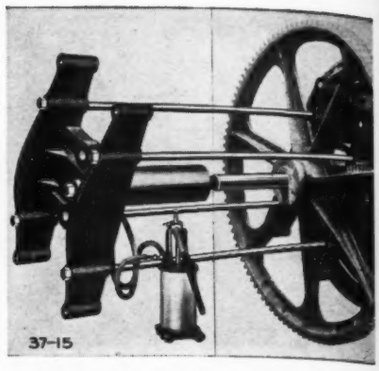
"TOLEDO"
TRADE-MARK REGISTERED

PORTABILITY — PRODUCTION

Portable Hydraulic Press

A NEW portable hydraulic press that can be used either as a puller, press, or jack is announced by the Bucyrus-Erie Company, South Milwaukee, Wisconsin. The Beco Press is made expressly for use on heavy machinery to press large gears on shafts, pull bevel pinions, pull drum-shaft gears, for press work on shovel gears, spiders, sprockets, swing shaft assembly, crowd shaft assembly, shipper shaft, and track mechanism. In addition it is ideal for use as a jack of capacity to 150 tons. As a jack the compact press cylinder (ram) weighing only 75 lb. is used to lift and can be set up in any position.

The Beco Portable Press includes a frame for press work weighing 310 lb., a 4-speed pump weighing 75 lb., a press cylinder or ram weighing 75 lb., and having a pressure capacity up to 150 tons, four alloy steel frame rods, a back plate, and high-pressure hose and valve connections. Special equipment available includes sprocket lugs, frame extension rods, connectors for extension rods, extra long high-pressure hose, angle-iron stand for frame, and frame for track repair work.



The Bucyrus-Erie Company will be glad to send bulletin S-115 describing the Beco Portable Hydraulic Press to those interested.

Going straight down . . .
COSTS COME DOWN, TOO,
WITH THESE THREE SURVEYING DEVICES

Self-Checking SURWEL GYROSCOPIC CLINOGRAPH **1**

"SURWEL" provides a map of the complete course of the well prepared from actual photographic records. It automatically makes two surveys at greatest speed, one going in and one while coming out of the hole.
Time required for making two surveys of a 6000 ft. hole on the wire line about two hours, on the drill pipe about four hours. (U. S. Patents 1,124,068; 1,812,994; 1,898,473; 1,959,141; 1,960,038; 2,006,556; 2,012,138; 2,012,152; 2,012,455; 2,012,456 and others pending.)

2. Self-Checking H-K CLINOGRAPH
(Hewitt-Kuster)

"H-K" designed for open holes only—provides permanent, accurate, photographic records of inclination and direction on paper discs five minutes after removing instruments from hole. (U. S. Patents 1,812,994; 2,027,642; 2,093,128 and others pending.)

3. Self-Checking SYFO CLINOGRAPH

"S Y F O"—used on a wire line, as a "Go-Devil" inside the drill stem, or on sand or bailing line in open hole—affords quick, inexpensive daily records of vertical deviation in drilling, without the use of dangerous acids. (U. S. Patents 1,962,634; 2,013,875 and others pending.)

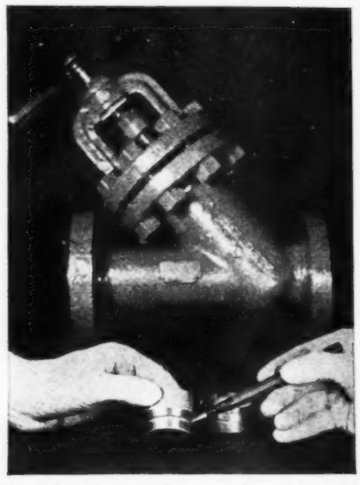
A New Service that Saves Time and Money
CORE ORIENTATION SERVICE

SPERRY-SUN'S Polar Core Orientation (U. S. Patents 1,792,639; 1,778,981; 2,089,216; 2,104,752 and others pending) does not interfere with the progress of drilling. The orientation is determined in our laboratory, to which the selected cores taken by any type of core barrel in the ordinary course of drilling and properly marked, are shipped from any distances. No special equipment is required at the well, there is no loss of drilling time.

SPERRY-SUN WELL SURVEYING COMPANY
1608 Walnut Street, Philadelphia, Pa.
Tulsa, Oklahoma 425 Petroleum Bldg. · Houston, Texas 5118 Blodgett Avenue · Corpus Christi, Texas 451 Southern Street · Long Beach, Calif. 549 E. Bixby Rd. (5800 Block Atlantic Avenue) · Bakersfield, Calif. c/o Elks Club 17th and I Streets · Lafayette, La. Bank of Lafayette Bldg.

Hancock Blow-Off Valve

THE Hancock Valve Division of Manning, Maxwell and Moore, Inc., Bridgeport, Connecticut, announces a full new line of boiler blow-off valves. This new line of Hancock valves incorporates numerous features, including the "Blo-Deflector" protecting lip. The makers claim that this design principle deflects boiler blow so effectively that these new valves are almost indestructible. To increase further the wear-resistance of these valves,



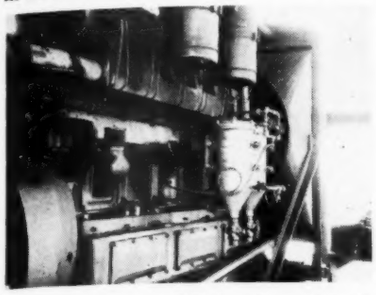
they have stainless-steel valve disks hardened to 500 Brinell and renewable valve seat rings heavily Stellited. It is further claimed by the makers that this combination of hard metals reduces maintenance cost to a minimum. Simplicity of design and fewness of parts are other claims for these valves.

The accompanying illustration shows the "Blo-Deflector" protecting lip on the 500 Brinell stainless-steel valve disk. In the background is seen a 2-in. straightway type.

These new Hancock blow-off valves are made in both straightway and angle types for boiler and economizer pressures to 1660 lb. in full compliance with A.S.M.E. code requirements.

Skinner Purifiers

SKINNER Purifiers, manufactured by Skinner Purifiers, Inc., 2231 Dalzelle Street, Detroit, Michigan, used to reclaim lubricating oil, are available in 21 standard models of the stationary



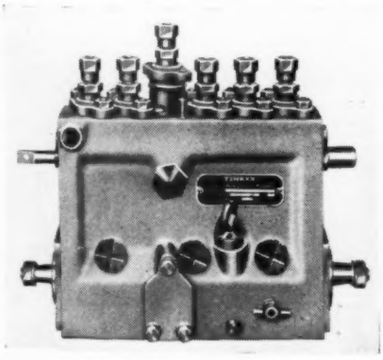
type and seven models for direct installation on the engine proper, the size and type of equipment being dependent upon the individual operator's requirements. Impurities are removed from the lubricating oil by filtering elements consisting of several hundred paper-thin disks that are held together by 80-lb. spring tension. The oil cannot pass through the disks, so must pass between them. Impurities are retained on the outer edge of the pack, the purified oil flowing from the filter through a passage through the center of the column of disks. The filter packs are cleaned by blowing with air in the reverse direction.

The manufacturer makes these claims for the purifiers: 94 to 97 percent of the total lubricating oil recovered; restores lubricating value equal to new oil; completely removes all contaminants.

In the Mid-Continent area J. P. Van Vorst, P. O. Box 262, Odessa, Texas, is the sales representative for Skinner Purifiers, Inc.

Renewable Pumping Units

RENEWABLE pumping units having a plunger diameter range of 4 mm. to 9 mm., for use in Timken fuel-injection pumps, were shown for the first time at the S.A.E. convention in Detroit, January 10-14. The units are pre-metered at the factory, thus eliminating the need for pump calibration or metering in the field at the time of installation, and they can be installed in a few minutes, the makers state.



The Timken renewable pumping unit is a self-contained, accurately-metered, precisely-timed mechanism, the makers say. It comprises in a rigid, simple unit body the barrel and plunger, the delivery valve, and the delivery valve spring. It is held tightly in the injection pump housing by two hexagon nuts threaded on two studs in the pump housing, pressing against a flange on the upper end of the pumping unit body. The pumping unit is positively aligned axially in the housing by the close fit in the housing bore and by one of the unit flange holes being accurately slotted to bear tightly on two sides of one of the precisely-placed dowel studs. Thus the unit must be correctly aligned to be inserted. The pumping unit slips easily into place and is tightened into the injection pump by means of the hexagon nuts until the unit flange seats firmly on a gasket against the flat top of the housing.

To assure calibration of one unit in relation to the other pumping units, the unit is so constructed that it can be slipped into the housing only when it is so set that the pinion gear on the upper metering sleeve will properly engage the correct teeth in the control rack rod of the injection pump.

The HIGHER STANDARD

SPANG FULL-CIRCLE SOCKET

You'll find this new type of Slip Socket efficient, and of very practical design. It is made of special steel—bored from a solid forging—scientifically heat treated to stand real abuse when its three slips take hold.

Consult SPANG on any cable-tool problem.

SPANG & COMPANY
BUTLER, PA.

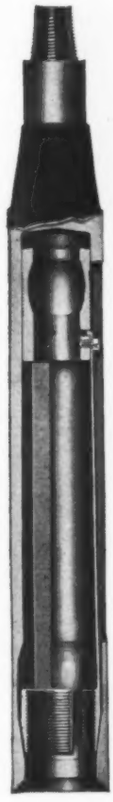


Fig. 626

Specify Spang
"HIGHER-STANDARD" CABLE TOOLS

IT'S THE *Cat's Whiskers*

FOR CLEANING OUT!

MILLER SAND PUMP

Because the MILLER — the Sand Pump with the powerful suction action, in world-wide use, quickly cleans out the sand in your wells, permitting free flowing of the oil.

The MILLER is made in diameters of 2½, 3, 3½, 4, 4¼, 5, 5½, 7 and 9 inches and lengths of 20, 25 and 30 feet. 5/32-inch wall thickness in REGULAR Type, ¼-inch wall tubes HEAVY Type Sand Pumps.

INTERCHANGEABLE BOTTOMS

To Meet Every Condition

- **BAILER BOTTOM**
  With the Bailer Bottom installed the MILLER is quickly changed to a Bailer giving you a combination of either Bailer or a Sand Pump in one tool.
- **SAND BOTTOM**
  Used when tools are run and when well is shot to quickly remove loose material.
- **STAR BOTTOM**
  Used for cutting the sand loose.
- **CHISEL BOTTOM**
  (In Pump)
  With this bottom tightly packed sand can be easily broken in small pieces so it can be picked up in the pump.

Write for Descriptive Folder and Price List

See Page 1186 COMPOSITE CATALOG

PATENTED
NO. 1370340
NO. 1523604
NO. 1787390
NO. 1962628
NO. 1966028
NO. 2055667

MILLER Sand Pump Co.

General Offices and Shop, Box 4516
OKLAHOMA CITY, OKLA., U. S. A.

Branch Shops and Offices:
SAPULPA, OKLA. and KILGORE, TEX.

FOR SALE BY SUPPLY STORES EVERYWHERE

Voltage Attachment for Tong Test Ammeter

COLUMBIA Electric Manufacturing Company, 4519 Hamilton Avenue, Cleveland, Ohio, announces a voltage attachment for its line of Tong Test Ammeters. The attachment is known as the Voltor and enables the operator to measure both a-c. and d-c.

voltages to 600 volts. Each Voltor affords the user three full ranges, namely, 0-150, 0-300, and 0-600 volts. These ranges can be changed by setting the rotary switch.

The Voltor is designed for use with any existing 50-amp. element either of type A or AX Tong Test or 75-amp. element of the type B or C. The Voltor is a self-contained unit weighing less than nine ounces, and is compact enough that it can be carried in the pocket.

The Voltor, in conjunction with the Tong Test, affords the user a complete voltage and current checking set for both a.c. and d.c., the complete outfit weighing three and one-fourth pounds, the manufacturers state.

Rayotube

IN several refineries, it is reported, the use of Fuller's earth or other low-cost filtering clay is now not only practical, but highly economical. For a way has been found to control so closely the temperature of clay being reactivated, that over-burning and under-burning of cheaper clays has been eliminated, with consequent increase in clay life, and in its filtering efficiency.

To make this possible, a Rayotube temperature detector mounts just outside the revivifying furnace; sights through a small hole directly on the clay as it is plowed across the hearth; continuously detects clay temperature (not temperature of gases surrounding the clay.) Ordinary leadwires connect Rayotube to a Micromax recorder, placed wherever desired. When operators want to "see" the temperature of clay passing through the furnace, they simply glance at a pointer moving across a clear Micromax indicating scale, and adjust controls accordingly. Or to see what the temperature has been in the past, they examine a wide Micromax strip-chart on which clay temperature is recorded automatically.

Used extensively for other industrial applications since 1932, Rayotube is said to hold its calibration and sensitivity reliably, to be virtually unaffected by vibration, to last for years.

This application of Rayotube-Micromax equipment is pictured and briefly described in Circular N33B-663 (1), a copy of which will be sent to anyone addressing Leeds & Northrup Company, 4934 Stenton Avenue, Philadelphia, Pennsylvania.

Heavy-Duty Automatic Lowering Jacks

THE Buda Company, Harvey, Illinois, announces the first model of a new line of heavy-duty automatic lowering jacks especially designed for oil-field service.

The Buda Emergency Jack No. 2215-H is the first model of the new line available for oil-field service. It is a hinged-type jack that permits operation at various angles. The 2215-H weighs 64 lb., has a 15-ton capacity, is 22 in. high, and has a rise of 13¾ inches.

Features claimed for the No. 2215-H jack is that the load may be raised or lowered on three sides of the jack without interference; that the automatic lowering device, which is an improved, simplified, adjustable, one-piece unit, is in full view of the operator, lessening the possibility of accidents during raising and lowering operations; and the jack is easily handled by a handle conveniently placed at the top of the jack.

Cunningham Promoted

John F. Cunningham, supervisor of production for the General Electric Company, Schenectady, New York, since September, 1931, has been appointed assistant to the vice-president in charge of manufacturing, succeeding Myron F. Simmons, who is retiring, it has been announced by W. R. Burrows, vice-president in charge of manufacturing.

JOHN F. CUNNINGHAM

Frank Collins, Executive Vice-President National Supply, Passes Away

Frank Collins, executive vice-president of the National Supply Company, and president of the Toledo Pipe Threading Machine Company, died at his home in Toledo, Ohio, on February 12 following a long illness. He was 67 years of age. As an executive of the National Supply Company, a firm that

FRANK COLLINS

is a pioneer in the oil-well supply business, he was an influential figure in the petroleum industry. In April of this year he would have observed the 51st anniversary of his first association with the company.

Collins was born in Toledo May 3, 1870. Because of the death of his father he was compelled to discontinue his formal schooling at the age of 16, at which time he went to work for National. He rose rapidly in the organization, eventually becoming the executive vice-president, the position he held at the time of his death.

In addition to his many activities in the petroleum industry he was prominent in numerous civic affairs in Toledo. The news of his death will be received with sadness by all those who knew him.

Besides his widow Collins is survived by Rushmore Sawyer, a half-brother, and Kate Sawyer, a half-sister, both of Toledo.

Stanbery New Manager of Continental Division

In keeping with a program calling for the expansion of the parts and service facilities for pumping equipment in 55 branch stores of the Continental Supply Company, the appointment of

R. B. "BOB" STANBERY

R. B. "Bob" Stanbery as manager of the Sub-surface Equipment Division was announced this week.

Long identified with the oil industry, Stanbery has been a special representative for Continental since 1935. Previously, he was associated with the D & B Pump and Supply Company, Los Angeles, California, manufacturers of pumping equipment for the Continental Supply Company. In this capacity, Stanbery was instrumental in the development of equipment to pump from present deep producing zones. His early experience was obtained with the Frick-Reid Supply Corporation in Ohio and the Superior Oil Corporation in California.

MacClatchie Barbecue

J. Warren MacClatchie, president of the MacClatchie Manufacturing Company, Compton, California, recently entertained members of the oil fraternity with a barbecue at his Double V Ranch at Saugus, California. Wyoming elk and pig from the MacClatchie ranch were prepared in the best Spanish style, and with baked beans and other fixin's provided a real oilman's feed.

MODERN DRILLING calls for a

Geared CATHEAD

The high speeds at which many line shafts are being run in today's drilling operations makes it practically imperative that a cathead be geared down to reduce the terrific impact when breaking tool joints. Conventional catheads, when slowed down, lose most of their power, but not the MacClatchie Gearomatic. Due to its patented gear arrangements, it rotates at HALF the line shaft speed yet gives DOUBLE the power.

It breaks the tightest joints with ease and without damage to tongs, tong dies, or other equipment.

A positive kick-out and slow motion insures greater safety. The positive kick-out permits one revolution, and only one, per pull. Consequently, there is no danger of fouled lines injuring workmen or damaging rig equipment when you use the MacClatchie Gearomatic Cathead.

MacCLATCHIE MANUFACTURING CO.

COMPTON, CALIF. HOUSTON, TEXAS

Export:

Geo. R. Woods, 17 Battery Pl., New York

R. W. NOBLE

Ralph Noble Transferred by Lufkin

Ralph Noble, for the last 11 years sales and service man for the Lufkin Foundry and Machine Company, Lufkin, Texas, has been transferred to Alice, Texas, where he will be in charge of the company's office and warehouse. Noble has had considerable experience in this type of work, having served in practically all the oil fields in the Mid-Continent and Gulf Coast areas.

Successful Sales Meeting Held

"The most successful sales meeting in years", was the consensus of 26 Macwhyte salesmen as they left Kenosha, Wisconsin, recently following a three-day national sales convention at the home offices of the Macwhyte Company, manufacturers of wire rope, braided wire rope slings, aircraft tie rods, etc.

Representing every section of the United States, the salesmen spent the first of three busy convention days in the famous Macwhyte laboratory observing while rigid tests given all Macwhyte products were demonstrated and explained by Walter Bloxdorf, well-known Macwhyte metallurgist.

Other conference highlights included an open forum discussion on sales problems in which all salesmen participated; a discussion of wire rope service by President Jessel S. Whyte; a review of sales accomplishments by H. E. Sawyer, general sales manager; and a discussion of markets and merchandising by A. B. Moseley, sales manager.

The conference closed with a banquet at which George S. Whyte, founder of the company and chairman of the board, and a pioneer in the wire rope industry, presided. Whyte made some interesting and pointed comparisons of progress made in the manufacture of wire rope, and foresaw increased activity in the wire rope industry during the coming year.

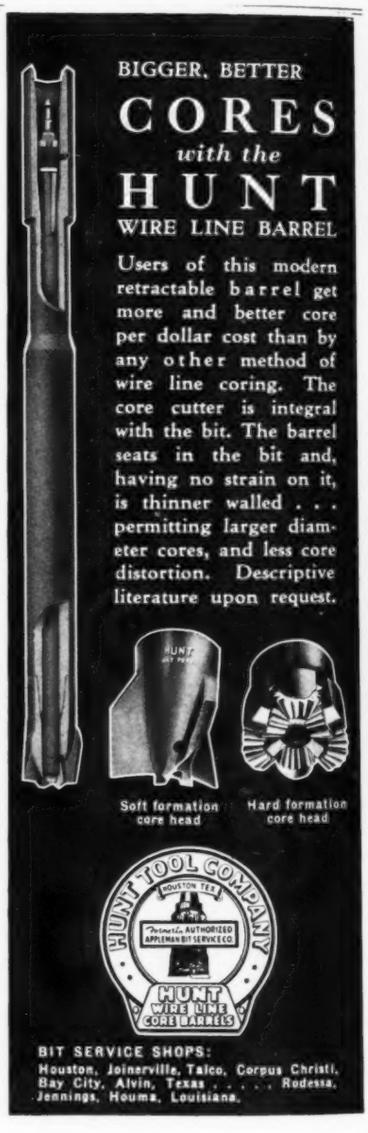
You'll Make MORE MONEY from That Well!

. . . if you equip it with a JENSEN Straight-Lift JACK. It's a DEPENDABLE unit, and its smooth, straight lift adds materially to the life of the other well equipment. Even if you are entirely satisfied with other equipment, we would appreciate an inquiry from you about JENSEN Units. We like to talk with producers. Sometimes we can make helpful suggestions. For 19 years all of our customers have been successful producers. Call your JENSEN dealer or . . .

Wire Us at COFFEYVILLE

JENSEN BROTHERS MANUFACTURING CO.

. . . Coffeyville, Kansas


BIGGER, BETTER
CORES
with the
HUNT
WIRE LINE BARREL
Users of this modern retractable barrel get more and better core per dollar cost than by any other method of wire line coring. The core cutter is integral with the bit. The barrel seats in the bit and, having no strain on it, is thinner walled . . . permitting larger diameter cores, and less core distortion. Descriptive literature upon request.
Soft formation core head
Hard formation core head
HUNT TOOL COMPANY
HOUSTON TEX.
Formerly AUTHORIZED APPLEMAN BIT SERVICE CO.
HUNT WIRE LINE CORE BARRELS
BIT SERVICE SHOPS:
Houston, Joinerville, Talco, Corpus Christi, Bay City, Alvin, Texas . . . . . Rodessa, Jennings, Houma, Louisiana.

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THE PETROLEUM ENGINEER,
Box 1589, Dallas, Texas.

Enter my subscription for one year. My check in the amount of $2.00 is enclosed.

*Name*_____

*Company*_____

*Position*_____

*Home Address*_____

*Office Address*_____

*City*_____ *State*_____

S. M. Jones Announces Two Promotions

The S. M. Jones Company announces the appointment of W. F. Slater as California district representative, and J. W. Lowes as Tulsa district representative.

W. F. SLATER

Slater received his engineering education from the University of Oklahoma, and his operating experience on his father's properties at Glenpool, and then became associated with the Field Engineering Department of The S. M. Jones Company. In 1936 Slater was appointed Tulsa district representative for the S. M. Jones Company and his experience in covering headquarters of many large Mid-Continent operators has given him a diversified acquaintance with pumping operators in such fields as Oklahoma City, Rodessa, West Texas, Gulf Coast, and Kansas. His promotion is an expansion move on the part of The S. M. Jones Company to effect better coördination of their manufacturing and field engineering services with the problems of the California producers.

J. W. LOWES

J. W. Lowes, a graduate of Carnegie Tech, first was associated with the Field Engineering Department of The S. M. Jones Company and later represented the company in Western Kansas. His technical education, combined with his practical field experience on sucker rod problems, also is in line with the company's policy of offering producers practical and technical assistance in obtaining the best results from Jones' products.

These appointments were effective February 1st.

Union Wire Rope "Talking Movie"

Every so often there is seen some outstanding bit of advertising. Sometimes it is pictorial, sometimes statistical, sometimes technical, and sometimes constructively educational.

In the last-named class is the new talking moving picture depicting in detail the complete processes of drawing high carbon rope wire and fabricating wire rope, as produced by the Union Wire Rope Corporation, of Kansas City, Missouri. This interesting and instructive picture is designed for presentation before groups in the building and construction, mining, logging, oil, and other industries in which wire rope is used extensively.

Oakite Division Managers Hold Conference

Improvements in cleaning practices relating to production and refinery maintenance were subjects discussed by division managers of Oakite Products, Inc., at their recent meeting at New York headquarters.

One such method is that developed for cleaning the water jackets of Diesel engines and other similar water-cooled equipment. Another eliminates laborious manual labor in cleaning from heat exchanger tubes scale that has been subjected to oil at high temperature and which has heretofore resisted removal by circulation methods. The third method is the control of algae and slime formations by preventive treatment of water in spray ponds and spray towers.

CUTS CLEANING OUT TIME IN HALF . . .

MIDCO
PLUNGER TYPE CLEAN-OUT
BAILER

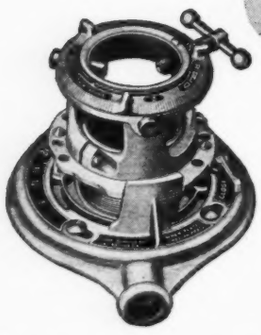
★ Helps Eliminate Fishing Jobs.
★ Interchangeable Heads and Bottoms Assure Extreme Adaptability.
★ Operates Safely—Efficiently.
★ Seamless Steel Tube Provides Maximum Strength and Ruggedness.
★ One Piece, Large Opening Patented Bottom Exclusive Feature.

MIDCO BAILERS have proved successful not only in Oklahoma City field where they are used by practically all operators but in other oil producing states as well. The Midco Bailer will pay you a profit over what you are trying to save with obsolete or inefficient equipment you might be using.

FOR RENTAL OR SALE
See Comp. Cat. Pgs. 1421-22

MIDCO
BAILER CO.
(Formerly Ideal Bailer Co.)
OKLAHOMA CITY, OKLA.
Pat. Nos. 2061489, 2090055, 2090209.
Other Patents Pending
IF IT'S MIDCO ITS MODERN

This RIDGID No. 65-R Threader Saves you time and bother Changing Dies!



You've got more important things to do than changing dies to thread 1", 1¼", 1½" and 2" pipe. And this RIDGID No. 65R saves you the trouble—all pipe, all threads.

For in this remarkable tool, the same set of dies threads all 4 sizes perfectly. Simply move setting post to size you want. No extra dies to lug around, to worry about losing.

Slick work-holder, too — sets quickly to pipe size, tightens with one screw.

A strong, beautifully balanced tool pleasing thousands by its fast clean work. Try it — you like the "feel" of it at once. Buy from your Supply House.

THE RIDGE TOOL CO., ELYRIA, O.

Stop Pipe Wrench Repairs

That RIDGID guarantee ends fully 75% of your pipe wrench repairs and wrenches out of service. More features you'll like than any other wrench. Buy today.

RIDGID PIPE TOOLS

Fitting Sucker Rods to Pumping Conditions

IN KEEPING with the recent trend toward selecting sucker rods on the basis of their ability to fit pumping conditions, The S. M. Jones Company of Toledo, Ohio, and Tulsa, Oklahoma, has just published a very comprehensive booklet covering the subject.

This illustrated booklet discusses the major pumping problems and the methods used to solve them. It outlines pumping conditions and the type of sucker rod to fit. It also contains some very interesting discussion on rod breaks. sucker rod strength and ductility tests, fatigue tests, hardness tests, and other brief discussions on technical subjects.

The background for these data covers many types of pumping conditions and many fields. Each type of Jones rod is carefully described. The physical and chemical characteristics, endurance limits, and photomicrographs are all given. Jones' services, which include the well study program, the "Care and Handling Booklet," as well as the talking picture, "Progress in Sucker Rods," are briefly discussed. Copies of this booklet may be procured by addressing The S. M. Jones Company, Tulsa, Oklahoma.

Changes in Grant Oil Tool Personnel

John Grant, president of the Grant Oil Tool Company, Los Angeles, California, has announced the following changes in and additions to personnel of his organization:

W. J. Grant, for several years production superintendent, has been made assistant general manager. John B. Shaw, formerly in the contracting business, also has been made an assistant general manager. George Shetlin, formerly connected with the sales departments of the Hughes Tool Company and the Baash-Ross Tool Company, has been named director of sales.

John Grant sailed from New York recently for an extended tour of South American oil fields and will not return until about May 1st.

W. J. Grant is traveling in the Mid-Continent and Gulf Coast fields to improve distribution and sales of Grant reamers, underreamers, wall-scrapers, hydrostatic bailers, and cleaners.

Changes Announced by Lane-Wells

Walter Wells, president of the Lane-Wells Company, Los Angeles, California, has announced a number of changes in company personnel, effective February 1, 1938. E. R. Smith has been transferred from Houston, Texas, where he was district manager, to the Los Angeles headquarters, where he has been assigned to the development of Lane-Wells service in foreign fields.

M. E. Montrose has been transferred from Oklahoma City, where he functioned as district manager, to Houston, Texas, where he became division manager.

R. B. McCullar, former assistant district manager at Oklahoma City, has been named division manager.

Bruce Barkis, with offices in Los Angeles, becomes manager of sales development. Barkis' work will cover all Lane-Wells services and products.

Norman Dorn has been named chief engineer in charge of operations for the Lane-Wells organization.

A SPECIALIZED WORKING BARREL FOR EVERY SERVICE

Select your Working Barrel for the service required! Hough offers you three *specialized* types—Seamless Steel, Cast Iron, and Seamless Bronze. Each one will give you long, efficient service.

Your oil-field distributor carries Hough Oil Well Specialties in stock. They are designed to *reduce pumping costs!*

THE CHARLES N. HOUGH MFG. COMPANY
FRANKLIN, PA., AND TULSA, OKLA.

"ON LOCATION" AND GIVING A SMOOTH PERFORMANCE

This Fulton Low Pressure Regulator is at work on the gas fuel line of a pump drawing oil from a deep well in Oklahoma. It might be in any place where pumping is done and pressure needs to be regulated. Chaplin-Fulton devices for controlling pressures of oil and other liquids, gas, air, or steam, have been standard for over fifty years. Ask for catalog.

THE CHAPLIN-FULTON MFG. COMPANY
28-40 Penn Ave.
PITTSBURGH, PA.

CF

TRAINED DOWN for Performance

"CLEVELANDS"

Stay with the Job and LICK IT!

DIGGING MORE DITCH — ON MORE JOBS — AT LESS COST

"Clevelands" are literally "trained down" like the champion athlete, with all dead weight eliminated and strengthened in every part from motor to digging wheel.

Powerful and rugged machines, they have the built-in qualifications to handle the toughest digging on the roughest rights-of-way — delivering superior performance on long lines with an absolute minimum of service interruptions.

Yet so compact, flexible, easily handled and transported that it pays to send them around to ditch small scattered jobs such as gathering and field lines. And "Clevelands" are quickly converted to strip existing lines for take-up and reconditioning.

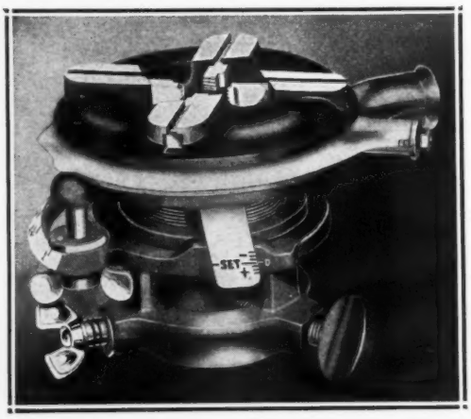
By unstintingly spending money on construction features, including a multitude of built-in speed combinations, 100% sealed self-lubricated gears, etc., "Cleveland" cuts down lost motion and waste effort, simplifying your operating problems.

More usable, highly efficient you'll find "Clevelands" in every respect the kind of equipment it's a pleasure to operate. Write today .. let us show you, without obligation, on your own work.

THE CLEVELAND TRENCHER COMPANY
"Pioneer of the Small Trencher"
20100 St. Clair Avenue **CLEVELAND, OHIO**

Another important "Cleveland" idea that helps you "come out right": high-speed, low-cost transportation via special trailer. "Clevelands" load and unload in 10 to 15 minutes. Thus machine savings are available on scattered short lines, "hot-spot" reconditioning, etc.

The BEAVER "12-R"
THREADS 1, 1¼, 1½, and 2 INCH
FOR SEVERE SERVICE

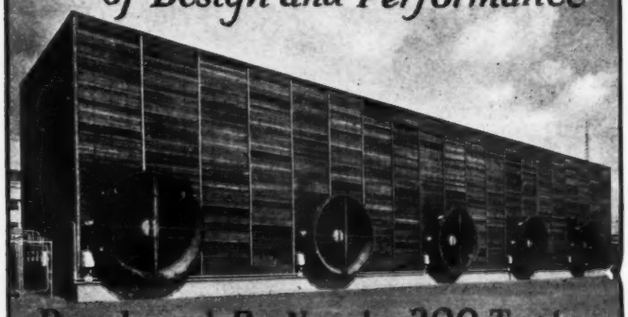


A "one-piece" tool (no loose parts) splendidly adapted to severe service. Well encased and protected against getting clogged up with sand and dirt; made of air-furnace malleable iron—entirely self-contained — no seperate parts to get mislaid when most needed; fully-adjustable for oversize or undersize threads; the ratchet pull is directly on the die head which facilitates easy pulling; it has the simplest and best centering device made—no mechanism to get out of order. Just a plain grooved bolt and washer. One of many BEAVER patents.

$15.00 — AT ALL SUPPLY HOUSES

BEAVER PIPE TOOLS
238 PETROL AVENUE WARREN, OHIO

All the Advantages of Design and Performance

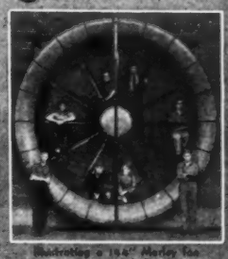


Developed By Nearly 300 Tests Under Actual Operating Conditions

Marley forced draft cooling towers provide the design and equipment proved best by nearly 300 tests. They conform in every way to the superior performance principles developed by those tests.

Nowhere else will you find more accurately rated forced draft towers or more definite assurance of maximum water cooling efficiency. Write for details.

THE MARLEY COMPANY
1915 Walnut Kansas City, Mo.



Illustrating a 154" Marley fan requiring a 25 H. P. motor.

MARLEY
FORCED DRAFT COOLING TOWERS

Trade Personals

JAMES BOYD, formerly assistant eastern district manager, has been appointed eastern district manager of the Westinghouse Electric and Manufacturing Company. He succeeds H. F. BOE, who has become commercial manager of the company, with offices in Pittsburgh. Boyd's headquarters will be in the Westinghouse Building at 150 Broadway, New York.

W. A. MEITER has been appointed manager of the Buffalo, New York, sales office of the Worthington Pump and Machinery Corporation of Harrison, New Jersey. He succeeds C. C. SCOTT, who will now devote his entire time to special work in the Buffalo district.

STUART M. CROCKER, vice-president of the International General Electric Company since 1930, has been appointed to the additional responsibilities of assistant to CHARLES E. WILSON, the new executive vice-president of the General Electric Company.

EDWARD F. CALLAHAN, general manager of apparatus sales of the International General Electric Company, has been elected a vice-president of the company, it has been announced by CLARK H. MINOR, president. Callahan has been in the employ of General Electric and the International General Electric for 33 years.

J. H. MITCHELL-ROBERTS, export manager for Oliver United Filters, Inc., left Manila on January 14th for Melbourne, Australia, where he will spend several months with the company's agent, Crossle and Duff Pty, Ltd.

ERNEST WOOLER, chief engineer of The Timken Roller Bearing Company, resigned recently and A. L. BERGSTROM has been appointed executive engineer to coördinate some of the varied engineering activities of the company. The company also has announced the following promotions in several divisions: R. M. Riblet to be chief engineer of the automotive division, J. B. Baker to be assistant chief engineer of the automotive division and chief engineer of the rock bit division. S. M. Weckstein has been appointed chief engineer of the industrial division; H. C. Edwards, chief engineer of the fuel injection equipment division; W. C. Makley, chief works engineer, and E. J. Reagan, general service manager.

W. P. WITHEROW, president of the Blaw-Knox Company, Pittsburgh, has announced the appointment of N. B. ORNITZ as president of the power piping division, and of W. N. QUARTZ as vice-president in charge of operations. Ornitz, a director and a vice-president of the Blaw-Knox Company, also will continue the management of the National Alloy Steel Division.

Percy Jones Addresses His Employees

A pamphlet containing a pithy speech by Percy C. Jones, president of The S. M. Jones Company, Toledo, Ohio, and addressed to employees of the company in the form of a Christmas letter, has come to the attention of the editors of *The Petroleum Engineer*. For the straightforward manner in which it discusses relationships between employee and employer and the effect certain government restrictions are having on business, it is of compelling interest. The pamphlet could be read with profit not only by all manufacturers, but by the whole rank and file of industry.

W. E. Ranney to Dallas for Henry Vogt Company

W. E. RANNEY

W. E. Ranney recently became connected with the Dallas, Texas, office of the Henry Vogt Company, whose headquarters are in Louisville, Kentucky. He is in charge of heat exchanger design for the southwest territory of the company.

Twin Disc Clutch Company Opens Dallas Branch

The Twin Disc Clutch Company, Racine, Wisconsin, has opened a branch in Dallas, Texas, which is under the direction of J. B. Jenkins, special oilfield factory representative, who also supervises the Tulsa, Oklahoma, branch. The Dallas branch is at 2826 Main Street and the telephone number is 7-1528.

A complete stock of replacement parts will be carried at all times for all special equipment used throughout the oil industry. Special oil-field engine service, data, and assistance will be offered to engineers and operators in this field.

L. W. Stahl Chief Engineer at Houston for Emsco

Emsco Derrick and Equipment Company, Los Angeles, California, announces the appointment of L. W. "Les" Stahl as chief engineer of the company's Houston Machinery Division with headquarters in Houston, Texas. Stahl first became connected with the Emsco organization early in 1937, and during the past year has been head of a new department created for the development of rotary drilling equipment.

L. W. "LES" STAHL

W. P. Chandler Passes Away

Williard P. Chandler, Jr., age 49, died January 24, at his home, 426 South Linden Avenue, Pittsburgh, Pennsylvania. Chandler was chief engineer of the industrial division of the Blaw-Knox Division of the Blaw-Knox Company and had been in the employ of the company since January, 1929.

WILLARD P. CHANDLER

ARMSTRONG BROS.

Dependable PIPE TOOLS

Certain to pay-out

There's no purpose in "wild-catting" on pipe tools when by specifying "ARMSTRONG BROS." you get tongs of proven strength and pipe tools with drop forged, hardened and alloy steel parts wherever they will add to strength or wearing quality. Each is an improved tool certain to pay out. Chains of ARMSTRONG BROS. Tongs are proof-tested to two-thirds of catalog strength (from 3,600 to 40,000 lb.) Jaws are drop forged from special steel, are treated, hardened and tested for wearing qualities, have forged-in lugs that give greater bearing on the bar, drop forged shackles and hardened steel bolts. Design improvement prevents chains from jamming.

ARMSTRONG BROS. Pipe Tools, *the most complete line manufactured, include:*

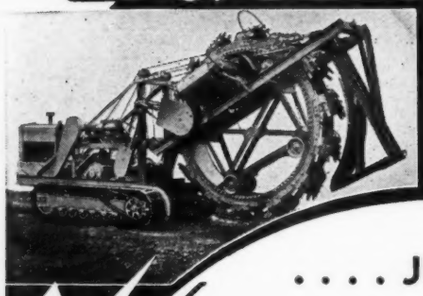
PIPE TOOLS
Solid Stocks and Dies
Adjustable Stocks and Dies
Receding Threaders and Chasers
Pipe Cutters and Wheels
Hinged and Chain Pipe Vises
Pipe Reamers
Pipe Wrenches

ARMSTRONG BROS. TOOL COMPANY

Eastern Warehouse and Sales: 199 Lafayette Street, New York, N. Y.
360 North Francisco Avenue, Chicago, U. S. A.

ARMSTRONG BROS. TOOL COMPANY
331 N. FRANCISCO AVE. CHICAGO, U. S. A.

Buckeye



Service Ditcher

. . . . JUST RIGHT

MODEL 12

for DITCH 15" to 24" WIDE

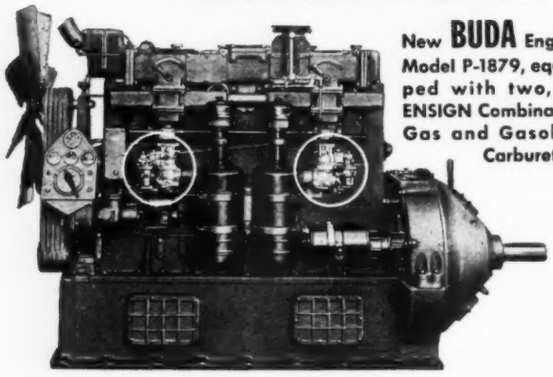
Some ditching looks easy — until you start. Or it may look plenty tough. But whether stony soil, restricted right of way, heavy time penalties in the contract, exactness required, or any of a dozen other difficulties confront you, a Buckeye Model 12 will see the job through on schedule.

It digs trench 15" to 24" wide to 5½' deep, at speeds ranging from 22" to 156" per minute. An additional sprocket gives 28' per minute. No soil short of solid rock can stop it. Complete facts are yours for the asking.

BID THE Buckeye WAY • ask for our operation data before you bid

THE BUCKEYE TRACTION DITCHER CO.
FINDLAY, OHIO, U. S. A.

LEADING ENGINE BUILDERS CHOOSE ENSIGN



New BUDA Engine, Model P-1879, equipped with two, 2" ENSIGN Combination Gas and Gasoline Carburetors.

Buda Engines are noted the world over for their *dependability!* ★ ENSIGN Gas, Combination Gas and Gasoline, and Butane Carburetors are *standard equipment* at the Buda factory and used *exclusively* by Buda's largest distributors.

★ *ENSIGN pioneered the development of carbureting equipment for dependable engine performance.*

ENSIGN CARBURETOR CO., LTD.
LOS ANGELES · DALLAS · CHICAGO

Exclusive Distributors for Smith Separators

The Parkersburg Rig and Reel Company became exclusive distributors of Smith Separators on January 1 of this year, and plans have been announced calling for improvement in the distribution and servicing of this well-known line. At present, stocks and service are available in Houston, Corpus Christi, Odessa, Willow Springs, and Pampa, Texas, and Rodessa, Louisiana. Within the near future, stocks and service also will be made available at convenient points in Kansas and California. Thereafter, as conditions justify, they will be added at other convenient points in Parkersburg's nationwide warehouse system. Supplies for fields in Oklahoma are to be handled direct from the Smith plant in Tulsa.

Fairbanks-Morse Moves General Offices

Fairbanks, Morse and Company have moved their general offices to the modernized Fairbanks-Morse building at 600 South Michigan Avenue, Chicago. This is but four blocks from the building at 900 South Wabash Avenue, which was the company's headquarters for a third of its 108 years.

The company's new quarters have been completely remodeled and redecorated. New facades on both its Michigan Avenue and Harrison Street sides give the building a modern appearance in keeping with its interior treatment. A new elevator system, attractive wood-paneled corridors, glass-block office partitions and other improvements combine practicality with attractiveness to provide ideal offices.

Novel Plan of Displaying Equipment Instituted

The Norvell-Wilder Supply Company has instituted a new plan at its Dallas and Fort Worth, Texas, offices for displaying oilfield equipment, which has proved exceptionally popular. Each week certain equipment is given a special display and buyers, engineers, production men, and young engineers who do not have much opportunity to see the equipment in the field are invited to view the exhibit.

During the week of January 10, at Dallas, Lunkenheimer valves and oilers were exhibited. Safety relief valves, pop valves, and a general line of brass and iron valves were displayed in cutaway models to show the different types of construction. During the week of January 24 equipment manufactured by the Hughes Tool Company was displayed, consisting of 3800-lb. tool joints, rock bits, and valves. The tool joints were bucked onto pipe and the whole cut in half lengthwise to show the types of equipment and connections. Rectorheads, manufactured by the Rector Well Equipment Company, Fort Worth, and Coffing hoists, manufactured by the Coffing Hoist Company, Danville, Illinois, were on display the week of February 7.

"Lip" Norvell and E. M. Frye, the latter Dallas manager, are responsible for the plan.

Robert S. Brown, Vice-President Basford Company, Dies

Robert S. Brown, vice-president and treasurer, G. M. Basford Company, New York advertising agency, died suddenly at his home in Rutherford, January 18.

Brown, who was 51 years old, joined the agency in 1916. Specializing in merchandising problems of the railway supply industry, Brown contributed greatly not only to the success of individual companies, but to the progress of industrial advertising as a whole. He especially had many friends in the oil industry.

Brown was an active member of Technical Publicity Association and National Industrial Advertisers Association for many years.

More Complete Scientific and Technical Exhibits Assured for Oil Show

More complete scientific and technical exhibits were assured for the 1938 International Petroleum Exposition at a joint meeting of the Exposition executive and scientific committees at Tulsa recently. The show, to be held from May 14 to 21, is obtaining exhibits that cost more than $250,000 to construct from the Chicago Museum of Science and Industry. These exhibits will cover every phase of the industry from exploration to the use of petroleum in the manufacture of face creams and asphalt.

Members of the committees present at the meeting included: D. C. Williams, Northern Oklahoma Gas Company, Ponca City, Oklahoma; M. F. Waters, Hanlon Waters, Inc., Tulsa; Dal Dalrymple, *Oil and Gas Journal*, Tulsa; A. C. Carlton, Museum of Science and Industry, Chicago; C. K. Francis, International Petroleum Exposition, Tulsa; A. J. Kerr, Midwest Equitable Meter Company, Tulsa; B. W. Logue, The Texas Company, Tulsa; R. E. Baker, Shell Petroleum Corporation, Tulsa; W. K. Carr, representing Clarel B. Mapes, Tulsa; K. K. Kimball, consulting geologist, Tulsa; L. W. Stinson, radio station KVOO, Tulsa; H. F. Goodenough, representing W. A. Schlueter, Refinery Supply Company, Tulsa; Frank B. Taylor, *Oil Weekly*, Tulsa; H. B. Powers, Bethlehem Supply Corporation, Tulsa; W. B. Berwald, representing N. A. C. Smith, United States Bureau of Mines, Bartlesville; H. A. Wilson, Bethlehem Supply Corporation, Tulsa; H. W. Camp, Cities Service Oil Company, Tulsa; Alf G. Heggem, Oil Well Improvements Company, Tulsa; Frank J. Hinderliter, Hinderliter Tool Company, Tulsa; L. F. Booth, Selby Oil and Gas Company, Tulsa; Wm. B. Way, International Petroleum Exposition, Tulsa; and Leslie Brooks, International Petroleum Exposition, Tulsa.

Another move on the part of Exposition officials that will prove popular is the decision to erect on the grounds a beautiful memorial monument to the pioneers of the oil industry. Contained in a vault in the monument will be the history of the successes and failures of the pioneers who have passed on who helped bring the oil game through its infancy to the important position it occupies today. Once every two years, during the exposition, the vault will be unsealed and the names and history of those who have gone since the last oil show will be added to the list and the vault will be resealed.

H. R. Gruber, vice-president in charge of oil country sales for the Union Wire Rope Corporation, and chairman of the Exposition's "old timers" committee, has announced the following committee members: C. L. McMahin, chairman of the historical sub-committee; Dal Dalrymple; B. M. Gessel; Charles Flint; Jim McIntire; J. K. McGoldrick; M. F. Waters; J. P. Flanagin, chairman of the memorial sub-committee; H. F. Sinclair; H. Ketchum; W. L. Connelly; E. F. Cremin; Nelson K. Moody; W. J. Stewart; J. J. Larkin; Fred Cook; Frank Wolfe; John Mabee; F. G. McClintock; G. F. Bell, chairman of the entertainment sub-committee; John Booker, chairman of the publicity sub-committee; Andy Rowley; Luther Williams; L. M. Ladet; Jack Casburn; Al Wall; Jim Downing; R. S. McBeth; Al Cashman, and Guy Tompson.

Gruber announces the historical sub-committee is accepting nominations for the "Grand Old Man of the Petroleum Industry." Candidates must have been actively engaged in the oil industry for at least 50 years. Nominations also are being accepted for the "Grand Old Man of Tulsa." Candidates must have been actively engaged in the oil business for at least 30 years and in Tulsa for 20 years.

11 Reasons why you, too, *will habitually specify*

B-M-W Admore

Insert Pump Anchors

1. This B-M-W Anchor seats the Admore Liner Barrel or other Insert Pumps at any desired point in the tubing.
2. Packs off and holds down directly in the tubing itself.
3. When the desired setting position is reached, the slips are tripped by lifting and turning the rods, and the packer is set by the weight of the rods.
4. Screws directly onto the pump, replacing the conventional cup or mechanical hold-down.
5. Saves on sucker rods and other equipment where high fluid level permits well to be pumped above bottom.
6. Pump runs in usual way, with no special care required.
7. Eliminates Working Barrels.
8. Eliminates Seating Nipples.
9. Eliminates Mechanical Shoes.
10. Eliminates Pulling of Tubing.
11. Cost is small compared with the savings.

Complete Data on Request

SUPPLY STORES SELL THEM

In addition to the above, leading B-M-W Products are sold at supply stores, including . . . ● NEILSON TOOLS (Safety Sucker Rod Hooks, Tubing Hooks, Rod Elevators, Sucker Rod Sockets, etc.); ● BALLS and SEATS (made for every pumping service); ● ADMORE Liner Barrels; ● TEX TYPE Plunger Fittings and Valves; and ● COLLINS Belt Clamps.

BRADFORD MOTOR WORKS INC.

OIL WELL SUPPLIES

BRADFORD, PA. — TULSA, OKLA.

SHULL SAND PUMP

(Self-unloading)

Many of the difficulties encountered in desanding operations are solved by this self-unloading sand pump. Working parts have been reduced to the minimum. Sticking in the casing is eliminated. It has an extra-long bailer tube. Loading and unloading are quickly accomplished and the fluid in the bailer washes the sand chamber clean. Greater strength is obtained by the use of a solid steel plunger instead of the conventional hollow-shaft. High vacuum is maintained in tubing with only a 11-foot stroke of the plunger.

See Composite Catalog or send coupon for full information

REQUEST FOR INFORMATION

Shull Perforating Co., Inc.,
2750 Cherry Ave., Long Beach, Calif.

Send full details regarding your new sand pump.
( ) Information about other Shull Products.

*Name*_____

*Address*_____

*City*_____ *State*_____

Here...
Oakite Cleaning
SAVED OVER $700
in tube replacement!

WHEN a thick, hard, carbonaceous deposit built up on the heat exchanger tubes in one refinery, cleaning by the usual methods was hopeless. To avoid the cost of a new set of tubes, the nearby Oakite Service Man was called in.

The tube bundle was soaked in a recently developed material and pressure washed in equipment made up at the refinery. When the bundle was finally steamed off the tubes were clean right down to the center baffles.

On your next cleaning problem get Oakite suggestions for economy, for speed, for production efficiency.

Manufactured only by
OAKITE PRODUCTS, INC., 48 Thames Street, New York, N. Y.
Branch Offices and Representatives in all Principal Cities of the U. S.

OAKITE *Certified* CLEANING
MATERIALS & METHODS FOR EVERY CLEANING REQUIREMENT

D-10
DURAMETALLIC
Twisted ALUMINUM FOIL PACKING FOR TEMPERATURES UP TO 1000° F.

ORIGINATED BY DURAMETALLIC

The original hot oil and high temperature flexibile metallic packing. Developed by Durametallic Engineers. Made only by the Durametallic Corporation, Kalamazoo, Michigan. Protected by U.S. Patents 1,464,604, 1,513,548 and 1,752,115 and Canadian Patent 243,939.

CONVINCING PROOF OF MONEY SAVING!
Comparison shown above illustrates how the light-weight Durametallic Grade D-10 gives more lineal feet per dollar than other flexible metallic packings.

FREE ENGINEERING COUNSEL ON YOUR PACKING PROBLEMS.
Write for literature and specification sheets

DURAMETALLIC CORPORATION
KALAMAZOO MICHIGAN
The PERFECT SEAL

TRADE LITERATURE

A NEW BOOKLET "Preventing Welding and Cutting Fires," just published, should be useful to all those interested in welding or cutting operations. The booklet is an important part of the nation-wide program to promote safe practices among the users of industrial equipment. Copies of this useful booklet may be obtained free upon request to any office of The Linde Air Products Company, New York and principal cities.

●

BULLETIN NO. 175 OF THE OIL WELL SUPPLY COMPANY, Dallas, Texas, is descriptive of the "Oilwell" Portable Superheated Steam Generator. A request directed to the manufacturer will bring a copy of the bulletin free.

●

AN ATTRACTIVE new bulletin, No. 38, has been issued by the Cavins Company, 2853-73 Cherry Avenue, Long Beach, California, illustrating and describing in detail the Cavins automatic hydraulic suction bailer and fishing tool. The principle of operation and its application in utilizing the potential energy of the fluid column in a well are graphically illustrated and described in this bulletin, which will be sent upon request to the manufacturer.

●

THE NEW RIGGERS' HANDBOOK of the Broderick and Bascom Rope Company, 4203 North Union Boulevard, St. Louis, Missouri, has just been published. This handbook contains a wealth of information concerning wire rope slings and fittings and the splicing and socketing of wire rope. A copy will be sent free upon request.

●

DOWELL INCORPORATED, Midland, Michigan, has issued an interesting and well-illustrated booklet describing methods the company employs in acidizing oil and gas wells. A copy can be obtained upon request to the company.

●

National Tank Company, Tulsa, Oklahoma, has issued bulletin No. 72 on Armco spiral-welded surface casing. In addition to describing the casing and pointing out its features the folder also contains a number of illustrations showing field uses.

●

A. M. BYERS COMPANY, Pittsburgh, Pennsylvania, has published a booklet entitled "101 Uses for Wrought Iron." The bulletin shows by means of pictures numerous ways in which wrought iron is used, each picture representing a different use.

●

IN CATALOG NO.36 OF THE O. C. KECKLEY COMPANY, Chicago, Illinois, are fully illustrated and described steam and liquid control equipment manufactured by the company. The publication is available upon request.

Will Present Paper at Metals Congress

GEORGE F. SCHERER

George F. Scherer, director of research for the Merco Nordstrom Valve Company, Oakland, California, will present a paper at the petroleum session of the Western Metals Congress, to be held in Los Angeles March 21-25. The title of the paper will be "Valves for the Petroleum Industry."

Guy E. Daniels Export Representative for Wilson Mfg. Co.

GUY E. DANIELS

Guy E. Daniels has been named export representative for the Wilson Manufacturing Company of Wichita Falls, Texas, manufacturers of portable rotary rigs and oilfield winches.

Transfers of field representatives also have been made within the Wilson organization. J. V. Wintle is now at Tulsa, Oklahoma, and is in charge of sales for Oklahoma and Kansas. Russell Moore, formerly sales representative in West Texas, has been transferred to South Texas with headquarters at Houston.

Mid-Continent Supply Company Opens Wichita Falls Store

The Mid-Continent Supply Company, with general offices in the Mid-Continent Building, Fort Worth, Texas, has opened a new store at Wichita Falls, Texas. This branch is under the supervision of O. B. Albritton, district manager, and the personnel includes: J. E. Snoddy, sales engineer; J. E. Everroad, sales engineer; W. E. Staples, Diesel service engineer, and R. M. Flippo, field salesman. The company also has district offices in the City National Bank Building at Wichita Falls.

The installation of this new branch was supervised by R. O. Moore, of Fort Worth, general merchandise manager for the Mid-Continent Supply Company.

James A. Sivalls Passes Away

James A. Sivalls, 71-year-old pioneer of the oil industry, died February 8 at his home in Bartlesville, Oklahoma, following an illness of three years. Sivalls founded the firm of Black, Sivalls and Bryson, Inc., 35 years ago. The headquarters of the company now is in Oklahoma City.

He was born in Woodville, Ohio, November 20, 1866. Shortly after reaching maturity, he moved to Findlay, Ohio, and became associated with Black Brothers, an oil tank manufacturing concern. He was connected with A. H. Black of Kansas City until the time of his death, and with E. F. Black of Tulsa until the latter's death ten years ago.

He is survived by the widow, Mrs. Hazel C. Sivalls; two sons, Charles of Oklahoma City, and Robert of Seminole, both sons being connected with his company; one brother, Stillwell, of Woodville, Ohio, and a sister, Miss Mary Sivalls.

Funeral services were held in Bartlesville and the body taken to Woodville, Ohio, for interment.

Revised Oil Map Issued

The Zingery Oil Map Company, Fair Building, Fort Worth, Texas, has issued its 1938 revised map covering Texas, eastern New Mexico, parts of southern Oklahoma, southwestern Arkansas, and Louisiana. This map shows all oil and gas fields discovered to date, and also contains a coördinated alphabetical list of the fields.

Gotkool
WATER CANS & COOLERS

GOTT WATER CAN
Made in 1½, 3, 5, and 10 gallon sizes.

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A DAILY REFERENCE FOR OPERATING MEN

INSTALLMENT NO. 9

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*This index is revised monthly as additional tables are published.
(a) In footnote, "feet" should read "inches."
(b) Headings "Redwood No. 1 seconds" and "Redwood admiralty seconds" should be transposed.

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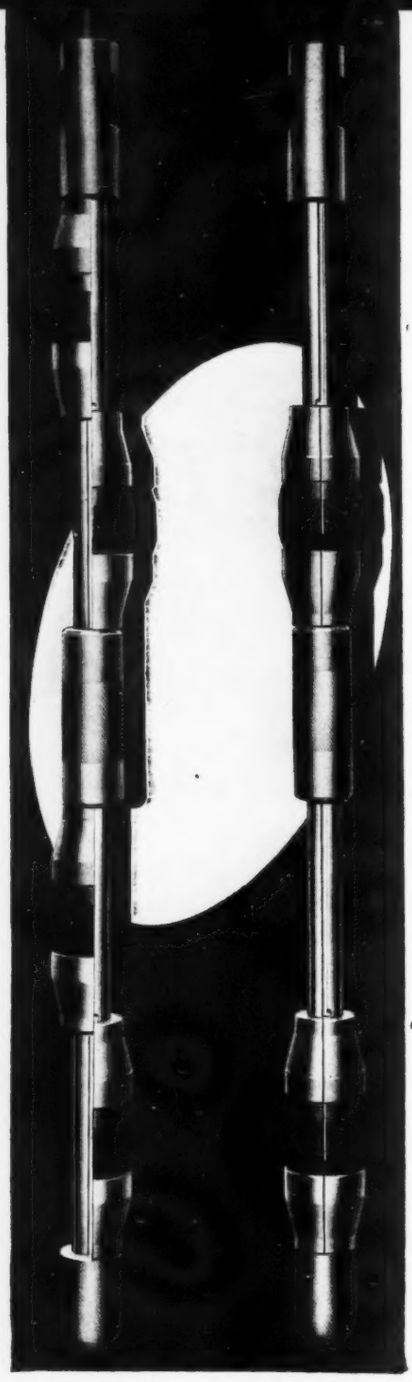
HYDROSTATIC PRESSURE,[1] LB. PER SQ. IN., OF FLUID COLUMNS OF DIFFERENT DENSITIES

Length of fluid column, ft.	Sp. gr. of fluid heavier than water				Fresh water (sp. gr.=1) (API gr.=10)	Gravity of fluid lighter than water, deg. A. P. I.									
	1.16	1.12	1.08	1.04		12	16	20	24	28	32	36	40	44	48
10	5.0	4.8	4.7	4.5	4.3	4.3	4.2	4.0	3.9	3.8	3.7	3.7	3.6	3.5	3.4
20	10.0	9.7	9.3	9.0	8.7	8.5	8.3	8.1	7.9	7.7	7.5	7.3	7.1	7.0	6.8
30	15.1	14.5	14.0	13.5	13.0	12.8	12.5	12.1	11.8	11.5	11.2	11.0	10.7	10.5	10.2
40	20.1	19.4	18.7	18.0	17.3	17.1	16.6	16.2	15.8	15.4	15.0	14.6	14.3	14.0	13.7
50	25.1	24.2	23.4	22.5	21.6	21.4	20.8	20.2	19.7	19.2	18.7	18.3	17.9	17.5	17.1
60	30.1	29.1	28.0	27.0	26.0	25.6	24.9	24.3	23.6	23.1	22.5	22.0	21.4	21.0	20.5
70	35.1	33.9	32.7	31.5	30.3	29.9	29.1	28.3	27.6	26.9	26.2	25.6	25.0	24.4	23.9
80	40.1	38.8	37.4	36.0	34.6	34.2	33.2	32.4	31.5	30.7	30.0	29.3	28.6	27.9	27.3
90	45.2	43.6	42.0	40.5	38.9	38.4	37.4	36.4	35.5	34.6	33.7	32.9	32.2	31.4	30.7
100	50.2	48.4	46.7	45.0	43.3	43	42	40	39	38	37	37	36	35	34
200	100	97	93	90	87	85	83	81	79	77	75	73	71	70	68
300	151	145	140	135	130	128	125	121	118	115	112	110	107	105	102
400	201	194	187	180	173	171	166	162	158	154	150	146	143	140	137
500	251	242	234	225	216	214	208	202	197	192	187	183	179	175	171
600	301	291	280	270	260	256	249	243	236	231	225	220	214	210	205
700	351	339	327	315	303	299	291	283	276	269	262	256	250	244	239
800	401	388	374	360	346	342	332	324	315	307	300	293	286	279	273
900	452	436	420	405	389	384	374	364	355	346	337	329	322	314	307
1000	502	484	467	450	433	427	415	405	394	384	375	366	357	349	341
1200	602	581	561	540	519	512	499	485	473	461	450	439	429	419	410
1400	702	678	654	630	606	598	582	566	552	538	525	512	500	489	478
1600	803	775	747	720	692	683	665	647	631	615	600	585	572	559	546
1800	903	872	841	810	779	769	748	728	709	692	675	659	643	629	615
2000	1003	969	934	900	865	854	831	809	788	768	750	732	715	698	683
2200	1104	1066	1028	990	952	940	914	890	867	845	825	805	786	768	751
2400	1204	1163	1121	1080	1038	1025	997	971	946	922	900	878	858	838	819
2600	1304	1259	1214	1169	1125	1110	1080	1052	1025	999	975	951	929	908	888
2800	1405	1356	1308	1259	1211	1196	1163	1133	1104	1076	1049	1025	1001	978	956
3000	1505	1453	1401	1349	1298	1281	1246	1214	1182	1153	1124	1098	1072	1048	1024
3200	1605	1550	1495	1439	1384	1367	1330	1295	1261	1230	1199	1171	1144	1118	1093
3400	1706	1647	1588	1529	1471	1452	1413	1375	1340	1306	1274	1244	1215	1187	1161
3600	1806	1744	1682	1619	1557	1538	1496	1456	1419	1383	1349	1317	1287	1257	1229
3800	1906	1841	1775	1709	1644	1623	1579	1537	1498	1460	1424	1390	1358	1327	1297
4000	2007	1938	1868	1799	1730	1708	1662	1618	1577	1537	1499	1464	1429	1397	1366
4200	2107	2034	1962	1889	1817	1794	1745	1699	1655	1614	1574	1537	1501	1467	1434
4400	2207	2131	2055	1979	1903	1879	1828	1780	1734	1691	1649	1610	1572	1537	1502
4600	2308	2228	2149	2069	1990	1965	1911	1861	1813	1767	1724	1683	1644	1606	1571
4800	2408	2325	2242	2159	2076	2050	1994	1942	1892	1844	1799	1756	1715	1676	1639
5000	2509	2422	2336	2249	2163	2135	2077	2023	1971	1921	1874	1829	1788	1746	1707
5500	2759	2664	2569	2474	2379	2349	2235	2225	2168	2113	2062	2012	1966	1921	1878
6000	3010	2906	2803	2699	2595	2563	2493	2427	2365	2305	2249	2195	2144	2095	2049
6500	3261	3149	3036	2924	2811	2776	2701	2629	2562	2497	2436	2378	2323	2270	2219
7000	3512	3391	3270	3149	3028	2990	2908	2832	2759	2690	2624	2561	2502	2445	2390
7500	3763	3633	3503	3374	3244	3203	3116	3034	2956	2882	2811	2744	2680	2619	2561
8000	4014	3875	3737	3598	3460	3417	3324	3236	3153	3074	2999	2927	2859	2794	2731
8500	4264	4117	3970	3823	3676	3630	3532	3439	3350	3266	3186	3110	3038	2968	2902
9000	4515	4360	4204	4048	3893	3844	3739	3641	3547	3458	3373	3293	3216	3143	3073
9500	4766	4602	4437	4273	4109	4057	3947	3843	3744	3650	3561	3476	3395	3318	3244
10000	5017	4844	4671	4498	4325	4271	4155	4045	3941	3842	3748	3659	3574	3492	3414

[1]At temperature at which gravity is measured. No allowance has been made for the lifting effect of any gas that may be present. Hence the figures given are maxima.



DOWN STROKE
Note that movable half of each rubber has raised above stationary half . . allowing an area for fluid passage much larger than that of conventional type swabs.

UP STROKE
Note that movable half of each rubber has dropped back beside its other half. Rubbers now in swabbing position.

FASTEST FALLING SWAB *In the World*

★ EARNS QUICKER PROFITS BY GETTING OIL INTO THE TANKS FASTER.

★ CUTS DOWN COSTS OF LABOR AND RIG RENTAL.

★ SWABS MORE WELLS PER DAY.

●

The 3 to 15 times faster swabbing of the

MISSION VALVELESS SWAB

is due to the unique split-rubber principle that permits unrestricted open flow.

●

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HUMBLE ROAD - HOUSTON, TEXAS

Mission Slips . . . Mission Valves . . . Mission Pistons . . . Mission Piston Rods . . . Mission Swabs

EXPORT OFFICE: 30 ROCKEFELLER PLAZA, NEW YORK

CORROSION IN REFINERIES

Equipment	Severe conditions: Corrosion	Severe conditions: Others	Resistant materials or remedy	Material normally used or in absence of severe conditions
Tubes, Topping	H_2S, oxidation, and H_2SO_3	400-900 deg. fahr.	0.5 Mo steel (mild conditions) 5 Cr steel (sometimes 1W) 18 Cr 8 Ni steel	0.2 C steel
Cracking	H_2S, oxidation	800-1200 deg. fahr. High pressure	5 Cr steel (or W or Mo) 18 Cr 8 Ni steel	0.2 C steel
Tube supports	High-temperature oxidation	1000-1500 deg. fahr. to 2100 deg. fahr.	12-16 Cr steel 35 Ni 5 Cr 10 Al rest Fe 28 Cr 8 Ni steel	
Return bends and headers	H_2S and oxidation		0.75 Cr 2 Ni cast steel 5 Cr steel	Cast steel
Plugs	H_2S and oxidation		Forged steel (tend to freeze) 22 Cr 1.8 Ni 1 Cu steel Monel or Munts Metal	Aluminum bronze Munts Metal
Stud bolts	Oxidation	Severe stress	1.5 Ni 0.7 Cr 0.8 Mn 0.4 C steel 1 Cr (or Mo) 0.4 C steel 8 Cr 20 Ni 1.25 Si 0.45 C steel (for corrosion)	Steel
Gaskets	H_2S and oxidation		Pure iron, pure aluminum, or stainless iron	Copper
Shells or chambers		High pressure	Thick steel 1-1.5 Mn 0.25 C steel 1-3.8 Ni 0.3 C steel 1 Cr 0.17 Va 0.3 C steel	0.2-0.3 C steel
	H_2S and HCl		18 Cr steel 18 Cr 8 Ni steel (or linings of these materials)	
Valve bodies	H_2S or HCl		2 Ni 0.75 Cr cast steel 5 Cr 1W 0.5 Mn steel	Forged or cast steel, cast iron, or brass
Trim	Oxidation, H_2S, or brine		12-14 Cr steel 20 Cr 8 Ni steel 5 Cr 0.5 Mo steel Nickel and Monel Metal	Brass or bronze
Fans for flue gas	High-temperature oxidation		12-14 Cr steel 18 Cr 8 Ni steel 70-30 Monel (fair)	Steel
Fractionating towers	HCl or H_2S, and H_2SO_3*		Neutralizing chemicals Thick steel or cast iron	Steel or cast iron
Bubble caps	HCl or H_2S, and H_2SO_3		Cast iron or rolled low alloy steel	Cast iron
Vapor lines	H_2S or HCl		Thick steel 18 Cr 8 Ni steel Neutralizing chemicals	Steel
Condensers, Tubular	HCl, hard water		Admiralty metal tubes Munts Metal tube sheets Cast iron shells	Steel tubes Cast-iron shells
	H_2S		5 Cr steel tubes 18 Cr 8 Ni steel tubes 1.5 Ni cast iron shells 18 Cr 8 Ni 2.5 Si shells	
Coil-in-box	H_2S or HCl, and hard water		Extra heavy pipe Cast iron class D Wrought iron Monel or Munts Metal bolts	Extra heavy pipe Cast-iron pipe
Treating, Agitators	H_2SO_4 concentrated H_2SO_4 dilute Sludge acid Caustic soda		Stee lor cast iron Sheet lead	Steel Lead
Lines and fittings	H_2SO_4 and NaOH		Lead-lined pipe Duriron	
Sweating pans	H_2O and trace of acid		Lining of Monel or aluminum	Steel
Storage tanks, Inside	H_2S and brine		Aluminum roof China wood oil paints, and varnishes Redwood	Stee
Outside	Oxidation and soil corrosion		Paints Dry porous foundations Copper-bearing steel	Steel
Pump plungers or rods	H_2S and HCl		12 to 14 Cr steel 1.5 Cr, 1.25 Al steel (if no acid)	Machine steel
Liners	H_2S and HCl		Nothing entirely satisfactory	Cast iron

*Pressure distillate rerun units

DEPENDABLE—AT DEWAXING TEMPERATURES

The relative toughness of steel at low temperatures is an important factor in its selection for equipment used in dewaxing plants. The performance of pumps, centrifuges and similar equipment can be considerably affected by the sub-zero impact strength of the steel in highly stressed parts.

Molybdenum steels, when properly heat-treated, have excellent impact properties at low temperatures. Investigation shows that they retain their toughness very well even at temperatures as low as —90° F.

They offer great possibilities to the maker of dewaxing equipment. Advantage can be taken of their established price and fabricating economy with perfect assurance of their performance.

We will be glad to send detailed information on the low-temperature impact properties of several well-known Molybdenum steels to any one interested. Climax Molybdenum Company, 500 Fifth Avenue, New York City.

PRODUCERS OF FERRO-MOLYBDENUM, CALCIUM MOLYBDATE AND MOLYBDENUM TRIOXIDE

CLIMAX MO-LYB-DEN-UM COMPANY **MOLY**

DECIMAL EQUIVALENTS OF COMMON FRACTIONS

1/64 .0156	17/64 .2656	33/64 .5156	49/64 .7656
1/32 .0312	9/32 .2812	17/32 .5312	25/32 .7812
3/64 .0469	19/64 .2969	35/64 .5469	51/64 .7969
1/16 .0625	5/16 .3125	9/16 .5625	13/16 .8125
5/64 .0781	21/64 .3281	37/64 .5781	53/64 .8281
3/32 .0937	11/32 .3437	19/32 .5937	27/32 .8437
7/64 .1094	23/64 .3594	39/64 .6094	55/64 .8594
1/8 .125	3/8 .375	5/8 .625	7/8 .875
9/64 .1406	25/64 .3906	41/64 .6406	57/64 .8906
5/32 .1562	13/32 .4062	21/32 .6562	29/32 .9062
11/64 .1719	27/64 .4219	43/64 .6719	59/64 .9219
3/16 .1875	7/16 .4375	11/16 .6875	15/16 .9375
13/64 .2031	29/64 .4531	45/64 .7031	61/64 .9531
7/32 .2187	15/32 .4687	23/32 .7187	31/32 .9687
15/64 .2344	31/64 .4844	47/64 .7344	63/64 .9844
1/4 .25	1/2 .50	3/4 .75	1 1.00

Longer Equipment Life with HYATT *Roller Bearings*

In drawworks, rotaries, pumps, swivels, blocks, etc., these dependable bearings are protection against wear and care. Build in Hyatts and your bearing difficulties are over.

Stops, starts, stresses, and strains call for *dependable* bearings. The millions of hours of carefree machine operation enjoyed every year are largely dependent upon the bearings that carry the load—and a large percentage of these bearings are Hyatt. Because they are designed right, built right, and applied right Hyatt Roller Bearings assure longer equipment life and more dependable operation wherever they serve.

HYATT BEARINGS DIVISION, General Motors Corporation, Harrison, N. J.

SPECIFIC GRAVITY OF CAUSTIC SODA SOLUTIONS AT VARIOUS TEMPERATURES

Weight percent of NaOH	Temperature of solution										
	15° C. 59° F.	18° C. 64.4° F.	20° C. 68° F.	30° C. 86° F.	40° C. 104° F.	50° C. 122° F.	60° C. 140° F.	70° C. 158° F.	80° C. 176° F.	90° C. 194° F.	100° C. 212° F.
0	0.9992	0.9987	0.9983	0.9958	0.9924	0.9882	0.9833	0.9779	0.9719	0.9655	0.9586
1	1.0106	1.0100	1.0095	1.0069	1.0033	0.9990	0.9941	0.9884	0.9824	0.9760	0.9693
2	1.0220	1.0213	1.0207	1.0177	1.0139	1.0095	1.0045	0.9989	0.9929	0.9865	0.9797
3	1.0332	1.0324	1.0318	1.0285	1.0246	1.0201	1.0150	1.0094	1.0035	0.9970	0.9903
4	1.0444	1.0435	1.0428	1.0393	1.0352	1.0305	1.0254	1.0198	1.0139	1.0075	1.0009
5	1.0555	1.0545	1.0538	1.0501	1.0458	1.0412	1.0359	1.0302	1.0243	1.0179	1.0115
6	1.0667	1.0656	1.0648	1.0609	1.0564	1.0517	1.0463	1.0407	1.0347	1.0284	1.0220
7	1.0778	1.0766	1.0758	1.0717	1.0672	1.0623	1.0569	1.0513	1.0453	1.0390	1.0326
8	1.0889	1.0877	1.0869	1.0826	1.0780	1.0730	1.0676	1.0619	1.0560	1.0497	1.0432
9	1.1000	1.0987	1.0979	1.0934	1.0887	1.0836	1.0782	1.0725	1.0665	1.0602	1.0537
10	1.1111	1.1098	1.1089	1.1043	1.0995	1.0942	1.0889	1.0831	1.0771	1.0708	1.0643
11	1.1222	1.1208	1.1199	1.1152	1.1102	1.1050	1.0995	1.0937	1.0877	1.0814	1.0749
12	1.1333	1.1319	1.1309	1.1261	1.1210	1.1157	1.1101	1.1043	1.0983	1.0920	1.0855
13	1.1444	1.1429	1.1420	1.1370	1.1319	1.1265	1.1208	1.1150	1.1089	1.1026	1.0960
14	1.1554	1.1540	1.1530	1.1480	1.1428	1.1373	1.1316	1.1257	1.1195	1.1132	1.1066
15	1.1665	1.1650	1.1640	1.1590	1.1536	1.1480	1.1424	1.1364	1.1302	1.1238	1.1172
16	1.1776	1.1761	1.1751	1.1699	1.1645	1.1588	1.1531	1.1471	1.1408	1.1343	1.1277
17	1.1887	1.1871	1.1862	1.1808	1.1804	1.1696	1.1638	1.1578	1.1514	1.1450	1.1383
18	1.1997	1.1982	1.1972	1.1918	1.1963	1.1805	1.1746	1.1685	1.1621	1.1556	1.1489
19	1.2108	1.2092	1.2082	1.2027	1.2021	1.1912	1.1853	1.1792	1.1727	1.1662	1.1594
20	1.2218	1.2202	1.2191	1.2136	1.2079	1.2020	1.1960	1.1898	1.1833	1.1768	1.1700
21	1.2328	1.2312	1.2301	1.2295	1.2188	1.2128	1.2067	1.2004	1.1940	1.1874	1.1806
22	1.2439	1.2422	1.2411	1.2454	1.2296	1.2236	1.2174	1.2111	1.2046	1.1980	1.1912
23	1.2548	1.2532	1.2520	1.2512	1.2404	1.2344	1.2281	1.2218	1.2152	1.2086	1.2018
24	1.2658	1.2641	1.2629	1.2571	1.2512	1.2451	1.2388	1.2324	1.2259	1.2192	1.2124
25	1.2768	1.2750	1.2738	1.2680	1.2620	1.2558	1.2496	1.2431	1.2366	1.2298	1.2230
26	1.2877	1.2860	1.2848	1.2789	1.2728	1.2666	1.2603	1.2538	1.2472	1.2405	1.2336
27	1.2986	1.2968	1.2956	1.2896	1.2835	1.2772	1.2708	1.2644	1.2577	1.2510	1.2441
28	1.3094	1.3076	1.3064	1.3002	1.2942	1.2878	1.2814	1.2750	1.2682	1.2615	1.2546
29	1.3202	1.3183	1.3172	1.3110	1.3048	1.2984	1.2920	1.2854	1.2787	1.2720	1.2650
30	1.3309	1.3290	1.3279	1.3217	1.3154	1.3090	1.3025	1.2959	1.2892	1.2824	1.2755
31	1.3414	1.3396	1.3384	1.3322	1.3258	1.3194	1.3128	1.3063	1.2994	1.2926	1.2858
32	1.3520	1.3502	1.3490	1.3427	1.3362	1.3298	1.3232	1.3165	1.3097	1.3029	1.2960
33	1.3624	1.3605	1.3593	1.3530	1.3464	1.3400	1.3333	1.3266	1.3198	1.3130	1.3060
34	1.3728	1.3708	1.3696	1.3632	1.3566	1.3501	1.3434	1.3367	1.3299	1.3230	1.3161
35	1.3830	1.3810	1.3798	1.3734	1.3667	1.3602	1.3534	1.3467	1.3398	1.3330	1.3260
36	1.3933	1.3913	1.3900	1.3835	1.3768	1.3702	1.3634	1.3567	1.3498	1.3429	1.3360
37	1.4034	1.4014	1.4000	1.3935	1.3868	1.3801	1.3733	1.3665	1.3596	1.3528	1.3458
38	1.4135	1.4115	1.4101	1.4035	1.3967	1.3900	1.3832	1.3763	1.3695	1.3626	1.3556
39	1.4234	1.4214	1.4200	1.4134	1.4066	1.3998	1.3930	1.3860	1.3792	1.3723	1.3653
40	1.4334	1.4314	1.4300	1.4232	1.4164	1.4095	1.4027	1.3958	1.3889	1.3820	1.3750
41	1.4432	1.4411	1.4397	1.4328	1.4260	1.4191	1.4122	1.4053	1.3984	1.3914	1.3845
42	1.4529	1.4508	1.4494	1.4425	1.4356	1.4287	1.4217	1.4148	1.4079	1.4009	1.3940
43	1.4624	1.4604	1.4590	1.4520	1.4450	1.4381	1.4311	1.4242	1.4172	1.4102	1.4034
44	1.4720	1.4699	1.4685	1.4615	1.4545	1.4475	1.4405	1.4335	1.4266	1.4196	1.4127
45	1.4816	1.4794	1.4779	1.4710	1.4640	1.4569	1.4499	1.4429	1.4360	1.4290	1.4221
46	1.4911	1.4890	1.4873	1.4805	1.4734	1.4663	1.4593	1.4523	1.4454	1.4384	1.4315
47	1.5006	1.4985	1.4969	1.4900	1.4828	1.4757	1.4687	1.4617	1.4548	1.4478	1.4409
48	1.5102	1.5080	1.5065	1.4994	1.4922	1.4851	1.4781	1.4711	1.4641	1.4572	1.4503
49	1.5196	1.5174	1.5159	1.5088	1.5016	1.4944	1.4874	1.4804	1.4734	1.4666	1.4596
50	1.5290	1.5268	1.5253	1.5181	1.5109	1.5038	1.4967	1.4897	1.4827	1.4759	1.4690

FOR LIQUID...GAS...STEAM

There's a Taylor Flow Meter to measure or control rate of flow with proved accuracy, efficiency, durability and economy in operation

Send for Special Taylor Catalog 70J—one of the most complete books on Flow (and Liquid Level) Instruments ever printed . . .

WHAT TYPE of instruments do you need for measuring or controlling rate of flow in your plant? Is it a comparatively simple matter of indicating or recording flow of a liquid . . . a gas . . . or steam? Is it a complex job of control?

No matter what your specific requirements are, you can make a selection of the correct instrument from the complete Taylor line. In these instruments you will find the modern refinements and improvements necessary to meet the severest demands in regulating continuous processes. You can be sure of the same accuracy, dependability, and economy that you obtain from Taylor Temperature and Pressure Instruments.

The many years of accurate, trouble-free service assured by Taylor Flow Meters help to make life easier and happier for a plant's management, its engineers and its foremen. The primary devices of these instruments are time-proved in principle and in actual operation. The secondary or measuring devices are standard Taylor Instruments with the outstanding features and advantages that have been known to major industries for a long, long time.

Taylor Flow Meters include the following:

DIAL TYPE INDICATORS . . . for liquids, or for gases or steam under constant pressure.

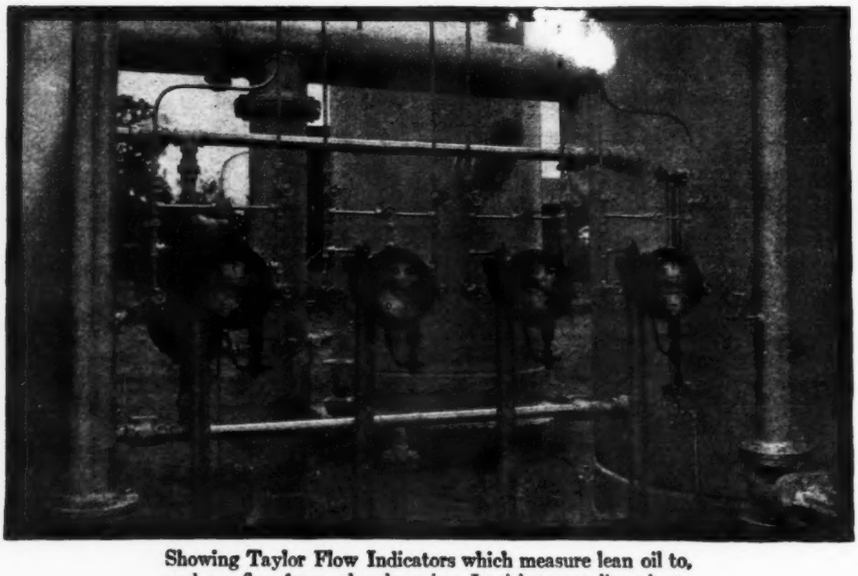
RECORDERS . . . single-pen types for liquids —two- and three-pen types for gases and steam.

INTEGRATING RECORDERS . . . for liquids —or for gases and steam.

CONTROLLERS . . . single-pen types for liquids—two- and three-pen types for gases and steam.

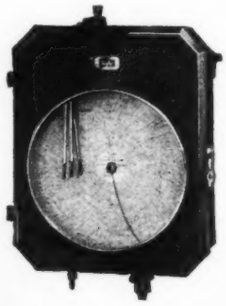
TIME-SCHEDULE CONTROLLERS; RE-SET CONTROLLERS; INDICATING FLOW CONTROLLERS and other types that you will see in Catalog 70J.

You really should have this Taylor Catalog 70J in your file. It is one of the most complete books on flow instruments ever put out by a manufacturer of instruments. (It tells about Taylor Liquid Level Instruments, too). It is so complete that in many cases you can select the instrument you need without any further inquiry. For this catalog and any help on control problems, ask a Taylor Representative, or write direct to Taylor Instrument Companies, Rochester, N. Y. Plant also in Toronto, Canada. Manufacturers in Great Britain—Short & Mason, Ltd., London, England.



Showing Taylor Flow Indicators which measure lean oil to, and gas flow from, absorbers in a Louisiana gasoline plant.

TAYLOR FLOW RECORDER. Single-pen type for liquids to record rate of flow directly, or differential pressure. Two-pen and three-pen types for gases and steam have graduated charts with scales for differential pressure and static pressure and/or temperature.



TAYLOR FULSCOPE INDICATING FLOW CONTROLLER for liquids . . . or for gases and steam under constant pressure. Flexible in design and completely adaptable to operating conditions and processing needs. For use in continuous processes where accurate throttling control is required.

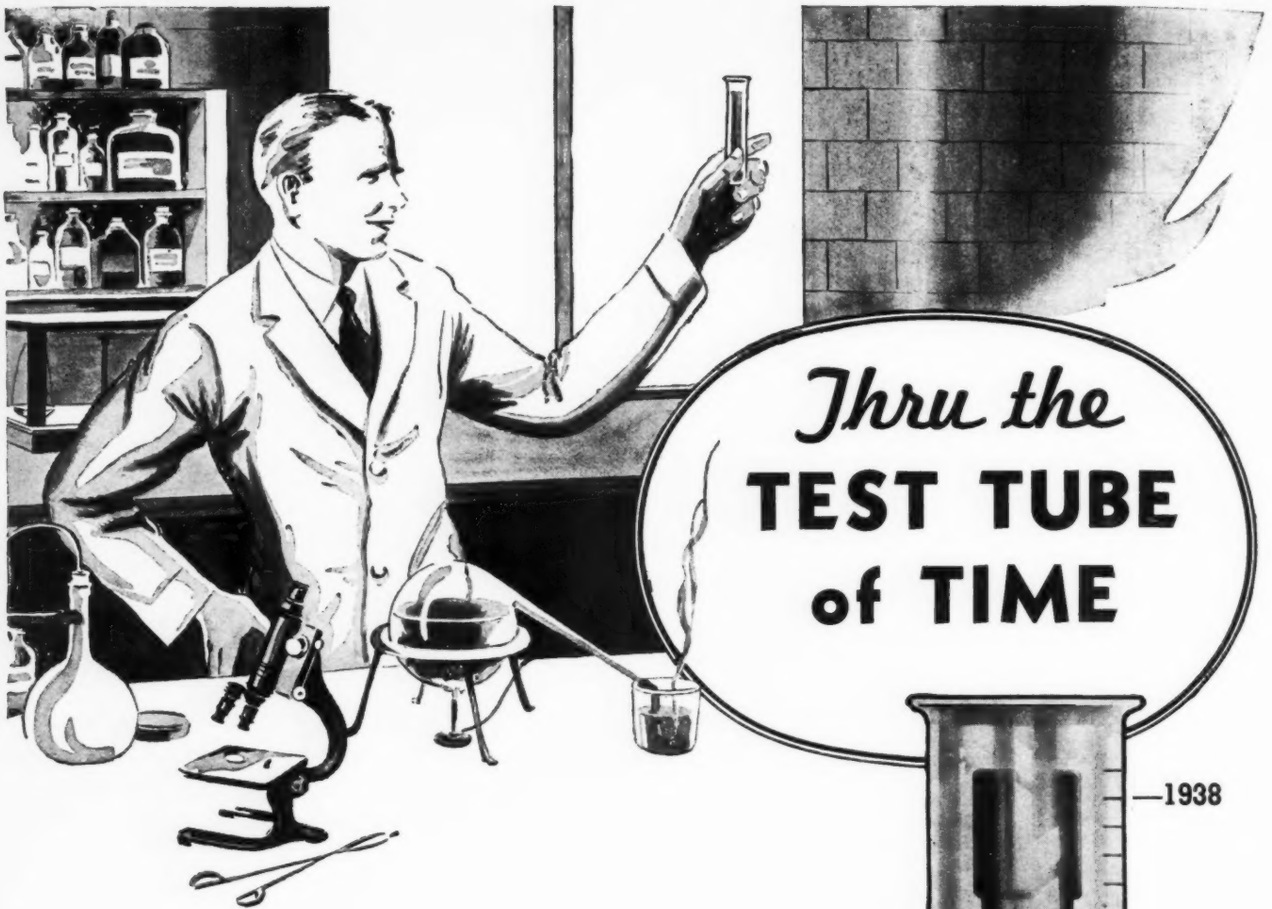
Taylor

Indicating Recording Controlling

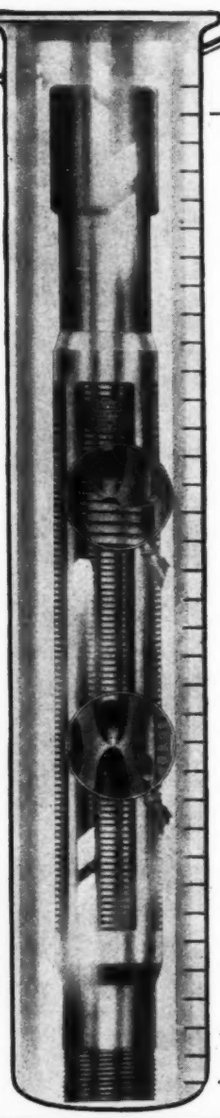
TEMPERATURE, PRESSURE, FLOW —*and* LEVEL INSTRUMENTS

PRESSURE OF INPUT WATER AT SAND FACE, LB. PER SQ. IN.

Depth to sand being flooded, ft.	Pump pressure, lb. per sq. in.																				
	0	25	50	75	100	125	150	175	200	225	250	275	300	325	350	375	400	425	450	475	500
50	22	47	72	97	122	147	172	197	222	247	272	297	322	347	372	397	422	447	472	497	522
100	43	68	93	118	143	168	193	218	243	268	293	318	343	368	393	418	443	468	493	518	543
150	65	90	115	140	165	190	215	240	265	290	315	340	365	390	415	440	465	490	515	540	565
200	87	112	137	162	187	212	237	262	287	312	337	362	387	412	437	462	487	512	537	562	587
250	109	134	159	184	209	234	259	284	309	334	359	384	409	434	459	484	509	534	559	584	609
300	130	155	180	205	230	255	280	305	330	355	380	405	430	455	480	505	530	555	580	605	630
350	152	177	202	227	252	277	302	327	352	377	402	427	452	477	502	527	552	577	602	627	652
400	174	199	224	249	274	299	324	349	374	399	424	449	474	499	524	549	574	599	624	649	674
450	195	220	245	270	295	320	345	370	395	420	445	470	495	520	545	570	595	620	645	670	695
500	217	242	267	292	317	342	367	392	417	442	467	492	517	542	567	592	617	642	667	692	717
550	239	264	289	314	339	364	389	414	439	464	489	514	539	564	589	614	639	664	689	714	739
600	260	285	310	335	360	385	410	435	460	485	510	535	560	585	610	635	660	685	710	735	760
650	282	307	332	357	382	407	432	457	482	507	532	557	582	607	632	657	682	707	732	757	782
700	304	329	354	379	404	429	454	479	504	529	554	579	604	629	654	679	704	729	754	779	804
750	326	351	376	401	426	451	476	501	526	551	576	601	626	651	676	701	726	751	776	801	826
800	347	372	397	422	447	472	497	522	547	572	597	622	647	672	697	722	747	772	797	822	847
850	369	394	419	444	469	494	519	544	569	594	619	644	669	694	719	744	769	794	819	844	869
900	391	416	441	466	491	516	541	566	591	616	641	666	691	716	741	766	791	816	841	866	891
950	412	437	462	487	512	537	562	587	612	637	662	687	712	737	762	787	812	837	862	887	912
1000	434	459	484	509	534	559	584	609	634	659	684	709	734	759	784	809	834	859	884	909	934
1050	456	481	506	531	556	581	606	631	656	681	706	731	756	781	806	831	856	881	906	931	956
1100	477	502	527	552	577	602	627	652	677	702	727	752	777	802	827	852	877	902	927	952	977
1150	499	524	549	574	599	624	649	674	699	724	749	774	799	824	849	874	899	924	949	974	999
1200	521	546	571	596	621	646	671	696	721	746	771	796	821	846	871	896	921	946	971	996	1021
1250	543	568	593	618	643	668	693	718	743	768	793	818	843	868	893	918	943	968	993	1018	1043
1300	564	589	614	639	664	689	714	739	764	789	814	839	864	889	914	939	964	989	1014	1039	1064
1350	586	611	636	661	686	711	736	761	786	811	836	861	886	911	936	961	986	1011	1036	1061	1086
1400	608	633	658	683	708	733	758	783	808	833	858	883	908	933	958	983	1008	1033	1058	1083	1108
1450	629	654	679	704	729	754	779	804	829	854	879	904	929	954	979	1004	1029	1054	1079	1104	1129
1500	651	676	701	726	751	776	801	826	851	876	901	926	951	976	1001	1026	1051	1076	1101	1126	1151
1550	673	698	723	748	773	798	823	848	873	898	923	948	973	998	1023	1048	1073	1098	1123	1148	1173
1600	694	719	744	769	794	819	844	869	894	919	944	969	994	1019	1044	1069	1094	1119	1144	1169	1194
1650	716	741	766	791	816	841	866	891	916	941	966	991	1016	1041	1066	1091	1116	1141	1166	1191	1216
1700	738	763	788	813	838	863	888	913	938	963	988	1013	1038	1063	1088	1113	1138	1163	1188	1213	1238
1750	760	785	810	835	860	885	910	935	960	985	1010	1035	1060	1085	1110	1135	1160	1185	1210	1235	1260



Thru the TEST TUBE of TIME



● The Layne Screen is a direct descendant of the first successful Oil Well Screen. Its origin dates back to the Spindletop field, where the need for screening first became apparent.

During the ensuing 34 years Layne Engineers and Field Men have constantly studied screening problems and the means to solve them.

As a result, the present Layne Screens are the ultimate in efficiency from every standpoint.

They lead in length of service, amount of oil produced, screening-quality, freedom of clogging and sand-cutting; design and manufacturing precision.

Protect your well investment by installing Layne Screen.

LAYNE & BOWLER COMPANY
HOUSTON, TEXAS
Export: Room 1636, 30 Rockefeller Plaza, New York, N. Y.

THE LAYNE SCREENS

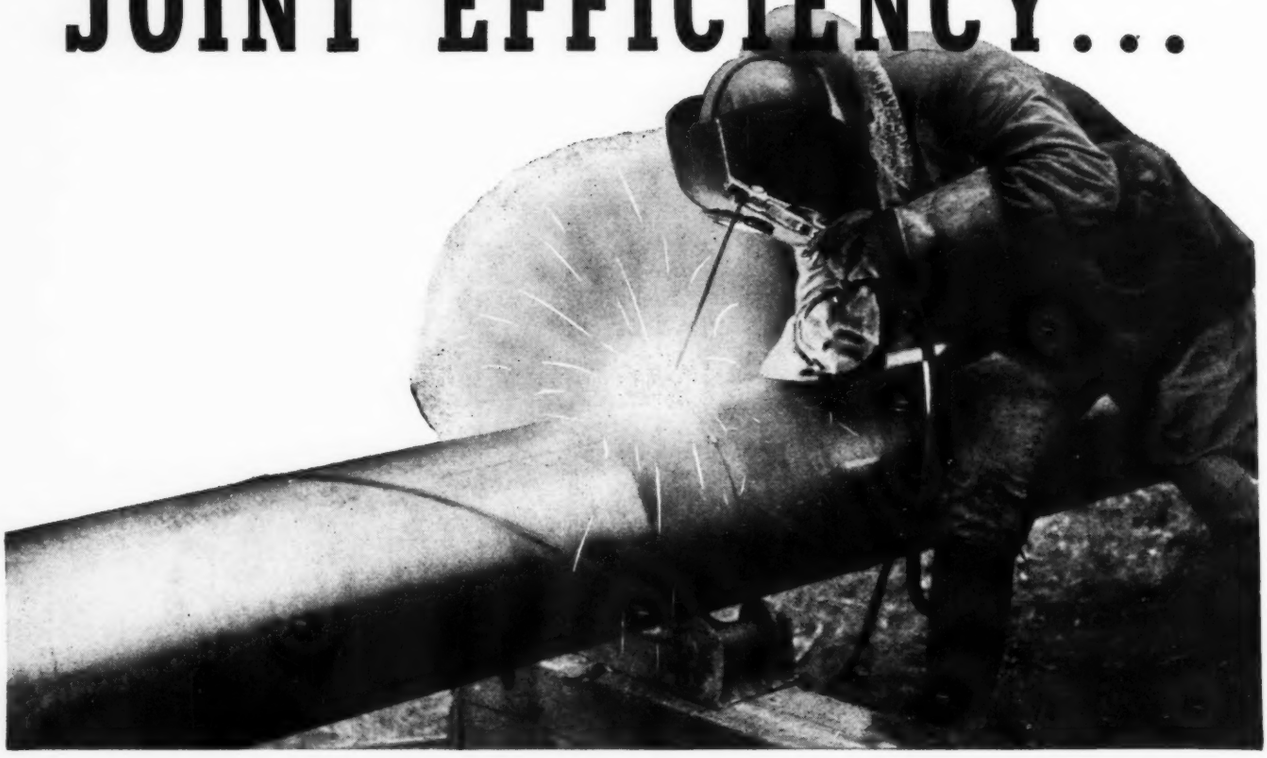
Milled Groove | Plain Drilled | Slotted Pipe

PRESSURE DROP, LB. PER SQ. IN. PER MILE OF 10-in.[1] PIPE LINE (Oil of 20° A.P.I.)

Quantity of 20° A.P.I. oil, bbl. per hr.	Viscosity of oil, Saybolt Universal seconds										
	140	160	180	200	220	240	260	280	300	320	340
650	5.63	5.84	6.03	6.21	6.37	6.53	6.67	6.80	6.93	7.06	7.18
675	6.01	6.24	6.45	6.63	6.80	6.97	7.12	7.27	7.40	7.53	7.67
700	6.40	6.65	6.87	7.06	7.25	7.43	7.59	7.74	7.89	8.02	8.16
725	6.80	7.08	7.31	7.51	7.70	7.90	8.07	8.23	8.38	8.53	8.67
750	7.22	7.50	7.75	7.97	8.17	8.37	8.56	8.73	8.89	9.04	9.20
775	7.64	7.93	8.19	8.44	8.65	8.86	9.05	9.23	9.41	9.57	9.73
800	8.07	8.38	8.66	8.91	9.14	9.36	9.56	9.76	9.94	10.11	10.28
825	8.51	8.84	9.14	9.40	9.65	9.88	10.08	10.29	10.49	10.66	10.84
850	8.97	9.31	9.63	9.90	10.17	10.40	10.62	10.85	11.04	11.24	11.43
875	9.44	9.80	10.12	10.42	10.70	10.94	11.18	11.40	11.61	11.82	12.02
900	9.90	10.28	10.62	10.94	11.23	11.49	11.73	11.97	12.19	12.40	12.61
925	10.38	10.78	11.14	11.48	11.77	12.06	12.30	12.55	12.79	13.01	13.23
950	10.87	11.30	11.67	12.03	12.34	12.64	12.89	13.15	13.39	13.63	13.86
975	11.39	11.83	12.22	12.58	12.92	13.22	13.49	13.76	14.01	14.26	14.50
1000	11.91	12.36	12.77	13.14	13.50	13.81	14.11	14.38	14.64	14.90	15.15
1025	12.43	12.90	13.33	13.71	14.09	14.42	14.74	15.01	15.29	15.56	15.81
1050	12.95	13.44	13.89	14.28	14.68	15.03	15.35	15.65	15.94	16.22	16.48
1075	13.50	14.00	14.47	14.89	15.29	15.66	16.00	16.32	16.62	16.89	17.16
1100	14.05	14.58	15.07	15.51	15.91	16.31	16.66	16.99	17.30	17.59	17.86
1125	14.59	15.16	15.67	16.12	16.54	16.96	17.32	17.66	17.99	18.28	18.58
1150	15.16	15.77	16.28	16.75	17.19	17.61	18.01	18.35	18.69	18.99	19.30
1175	15.72	16.35	16.89	17.38	17.84	18.26	18.67	19.05	19.41	19.72	20.03
1200	16.31	16.97	17.52	18.03	18.51	18.95	19.38	19.75	20.13	20.47	20.77
1225	16.89	17.58	18.15	18.68	19.18	19.62	20.09	20.48	20.87	21.22	21.54
1250	17.49	18.22	18.81	19.36	19.88	20.32	20.80	21.21	21.60	21.99	22.32
1275	18.11	18.86	19.47	20.05	20.57	21.05	21.51	21.98	22.36	22.76	23.11
1300	18.73	19.49	20.15	20.73	21.27	21.79	22.25	22.73	23.13	23.55	23.91
1325	19.34	20.13	20.82	21.42	21.98	22.50	22.98	23.48	23.91	24.33	24.72
1350	19.97	20.79	21.50	22.13	22.71	23.25	23.75	24.24	24.70	25.13	25.54
1375	20.61	21.46	22.22	22.85	23.45	24.01	24.52	25.02	25.51	25.93	26.36
1400	21.27	22.13	22.94	23.57	24.20	24.78	25.31	25.82	26.33	26.77	27.21
1425	21.92	22.81	23.65	24.33	24.95	25.55	26.11	26.63	27.14	27.62	28.08
1450	22.59	23.49	24.36	25.05	25.70	26.32	26.89	27.44	27.96	28.46	28.91
1475	23.28	24.20	25.08	25.82	26.49	27.11	27.70	28.27	28.81	29.33	29.79
1500	23.97	24.93	25.80	26.60	27.27	27.93	28.55	29.11	29.64	30.20	30.68
1525	24.66	25.65	26.54	27.36	28.08	28.74	29.37	29.95	30.50	31.08	31.57
1550	25.37	26.39	27.30	28.15	28.89	29.58	30.20	30.80	31.37	31.96	32.48
1575	26.08	27.10	28.04	28.95	29.72	30.42	31.07	31.69	32.27	32.86	33.42
1600	26.78	27.84	28.81	29.75	30.54	31.23	31.90	32.57	33.14	33.75	34.32
1625	27.53	28.59	29.59	30.56	31.38	32.09	32.78	33.47	34.06	34.66	35.25
1650	28.26	29.35	30.39	31.35	32.22	32.96	33.67	34.35	34.99	35.57	36.19
1675	28.99	30.12	31.22	32.18	33.08	33.84	34.57	35.27	35.93	36.53	37.16
1700	29.73	30.93	32.02	33.01	33.94	34.72	35.48	36.19	36.84	37.49	38.11
1725	30.46	31.73	32.82	33.84	34.79	35.60	36.37	37.11	37.78	38.45	39.05
1750	31.24	32.51	33.67	34.68	35.66	36.50	37.29	38.05	38.74	39.43	40.05
1775	32.03	33.34	34.49	35.54	36.54	37.44	38.22	39.00	39.71	40.42	41.05
1800	32.79	34.17	35.32	36.39	37.43	38.35	39.15	39.96	40.69	41.42	42.07
1825	33.59	35.01	36.19	37.26	38.36	39.31	40.10	40.92	41.67	42.42	43.09
1850	34.40	35.82	37.03	38.17	39.26	40.23	41.08	41.89	42.66	43.43	44.16
1875	35.20	36.65	37.90	39.07	40.15	41.19	42.06	42.89	43.68	44.43	45.18
1900	36.02	37.47	38.79	39.99	41.06	42.17	43.02	43.88	44.69	45.46	46.23
1925	36.84	38.33	39.69	40.88	42.02	43.11	44.03	44.87	45.74	46.53	47.28
1950	37.67	39.20	40.60	41.81	42.94	44.11	45.05	45.91	46.76	47.57	48.38
1975	38.51	40.08	41.51	42.76	43.91	45.06	46.08	46.96	47.83	48.62	49.50
2000	39.40	40.96	42.43	43.71	44.84	46.03	47.07	48.01	48.91	49.72	50.57
2025	40.23	41.83	43.34	44.60	45.81	47.02	48.09	49.01	49.94	50.81	51.63
2050	41.13	42.72	44.27	45.56	46.80	48.00	49.14	50.08	50.98	51.93	52.77
2075	41.99	43.62	45.20	46.53	47.80	48.97	50.20	51.17	52.08	53.00	53.87
2100	42.91	44.53	46.14	47.50	48.81	50.01	51.21	52.25	53.19	54.13	54.97
2125	43.83	45.44	47.09	48.48	49.82	51.05	52.28	53.35	54.31	55.27	56.13
2150	44.69	46.39	48.03	49.51	50.87	52.08	53.34	54.43	55.41	56.40	57.27
2175	45.63	47.31	48.99	50.50	51.90	53.13	54.42	55.54	56.55	57.50	58.45
2200	46.57	48.29	49.95	51.50	52.93	54.19	55.45	56.65	57.68	58.66	59.63
2225	47.52	49.22	50.92	52.50	53.97	55.26	56.55	57.78	58.83	59.83	60.82
2250	48.42	50.22	51.90	53.57	55.01	56.39	57.65	58.91	59.99	61.00	62.02

[1]32.75 lb. per ft. For 35.75 lb. line pipe the pressure drop is about 2.6% greater and for 41.85 lb. line pipe it is about 7.8% greater.

100%
JOINT EFFICIENCY...

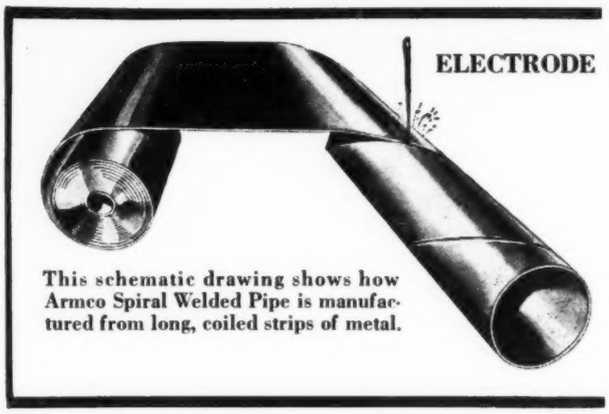


IN BOTH
PIPE AND FIELD WELDS

Oil men know from experience that the spiral welded joint on Armco pipe is *as strong as the steel itself.* And that means strength well in excess of your requirements.

Then too, since Armco Spiral Welded Pipe is supplied with plain bevelled ends, it can be *field welded faster and more economically* than heavy-end pipe. You'll also find that the finished welds are more ductile and uniform because only metals of the finest welding quality are used in the manufacture of Armco pipe.

Gain these extra advantages by ordering Armco Spiral Welded Pipe for that next gas gathering line or short transmission line. Diameters range from 6 to 36 inches; wall thicknesses from $\frac{7}{64}$ to $\frac{1}{2}$-inch, with individual lengths, fittings and coatings as required. Address: The American Rolling Mill Co., Pipe Sales Division, 703 Curtis Street, Middletown, Ohio, or 538 Mayo Building, Tulsa, Okla.



This schematic drawing shows how Armco Spiral Welded Pipe is manufactured from long, coiled strips of metal.

ARMCO

ARMCO SPIRAL WELDED PIPE

CLEARANCE BETWEEN CASING STRINGS, IN.

Size of outer string,		Size of inner string, O. D., in.																						
O.D., in.	I.D., in.	4¾	5	5½	5¾	6	6⅝	7	7⅝	8	8⅛	8⅝	9	9⅝	10	10¾	11¾	12	13	13⅜	14	16	18⅝	20	21½
6⅝	6.049	.649	.524																						
	5.989	.619	.494																						
	5.921	.585	.460																						
	5.855	.552	.427																						
	5.791	.520	.395																						
7	6.538	.894	.769	.519																					
	6.456	.853	.728	.478																					
	6.398	.824	.699	.449																					
	6.336	.793	.668	.418																					
	6.276	.763	.638	.388																					
	6.214	.732	.607	.357																					
	6.154	.702	.577	.327																					
	5.736	.493	.368																						
7⅝	6.969	1.109	.984	.734	.609	.484																			
	6.875	1.062	.937	.687	.562	.437																			
	6.765	1.007	.882	.632	.507																				
8	7.386	1.318	1.193	.943	.818	.693																			
8⅛	7.485	1.367	1.242	.992	.867	.742	.430																		
	7.385	1.317	1.192	.942	.817	.692																			
	7.285	1.267	1.142	.892	.767	.642																			
	7.185	1.217	1.092	.842	.717	.592																			
8⅝	8.017	1.633	1.508	1.258	1.133	1.008	.696	.508																	
	7.921	1.585	1.460	1.210	1.085	.960	.648	.460																	
	7.825	1.537	1.412	1.162	1.037	.912	.600	.412																	
	7.775	1.512	1.387	1.137	1.012	.887	.575	.387																	
	7.651	1.450	1.325	1.075	.950	.825	.513																		
9	8.290	1.770	1.645	1.395	1.270	1.145	.832	.645																	
	8.196	1.723	1.598	1.348	1.223	1.098	.785	.598																	
	8.150	1.700	1.575	1.325	1.200	1.075	.762	.575																	
	8.032	1.641	1.516	1.266	1.141	1.016	.703	.516																	
9⅝	8.921	2.085	1.960	1.710	1.585	1.460	1.148	.960	.648	.460															
	8.885	2.067	1.942	1.692	1.567	1.442	1.130	.942	.630																
	8.835	2.042	1.917	1.667	1.542	1.417	1.105	.917	.605																
	8.799	2.024	1.899	1.649	1.524	1.399	1.087	.899	.587																
	8.755	2.002	1.877	1.627	1.502	1.377	1.065	.877	.565																

CHESTER High Tensile Steel Casing

has a **BRINNELL** *hardness of 140 Minimum*

The Brinnell test is but part of the extensive and rigid examination to which Chester High Tensile Steel Casing must be subjected before it leaves the plant.

Because of these exact tests — and because of the successful performance of thousands of *strings* now in use— we can assure prospective users that Chester casing will stand up to the toughest service. We can promise new freedom from damaged threads in handling — and an almost complete elimination of burnt thread in making up.

When you specify Chester High Tensile Steel Casing, you can expect a steel casing that will fill *all* your requirements — with room to spare.

South Chester Tube Co.
Chester, Pa.

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F. H. Gibson, 1331 Gulf Bldg., Pittsburgh, Pa.
J. P. Cooney, 715-716 A. G. Bartlett Bldg., Los Angeles, Calif.
J. P. Steele, Petroleum Bldg., Fort Worth, Texas.

District Offices

South Chester Tube Co., 1708 Hudson Terminal Bldg., 30 Church St., New York, N. Y.
J. D. Swartz, Beacon Bldg., Tulsa, Oklahoma.
E. L. Moseley, 2218 Mills St., Houston, Texas.

District Warehouses

Houston, Tex.; Thenard, Calif.; San Francisco, Calif.

Distributors

Western Supply Co., Tulsa, Okla., and Branches.
International Supply Co., Tulsa, Okla., and Branches.
Dunigan Tool & Supply Co., Breckenridge, Texas, and Branches.
Bridgeport Machine Co., Wichita, Kansas, and Branches.
Louisiana Supply Co., Sulphur and Brimstone, La.
Industrial Supply Company, Inc., Wichita Falls, Texas, and Branches.
Decker Tool & Supply Co., Electra, Texas, and Branches.
J. E. Matthews, Ranger, Texas.
Stephen H. McCabe, 508 4th St., San Francisco, Calif.
Viking Automatic Sprinkler Co., 2715 East 12th St., Los Angeles, Calif.
Herley Supply Co., 3006 Cherry Ave., Long Beach, Calif.
Tubular Sales Co., 811 W. Seventh St. Bldg., Los Angeles, Calif.
Barde Steel Co., Seattle, Wash., and Portland, Ore.
Star Drilling Machine Co., 550 Clinton St., Portland, Ore., and Akron, Ohio.
The Atha Supply Co., Zanesville, Ohio, and Mt. Pleasant, Mich.
United Pipe & Supply Corp., Charleston, W. Va., and Branches.
Prichard Supply Co., Mannington, W. Va., and Branches.

CHESTER
STEEL CASING